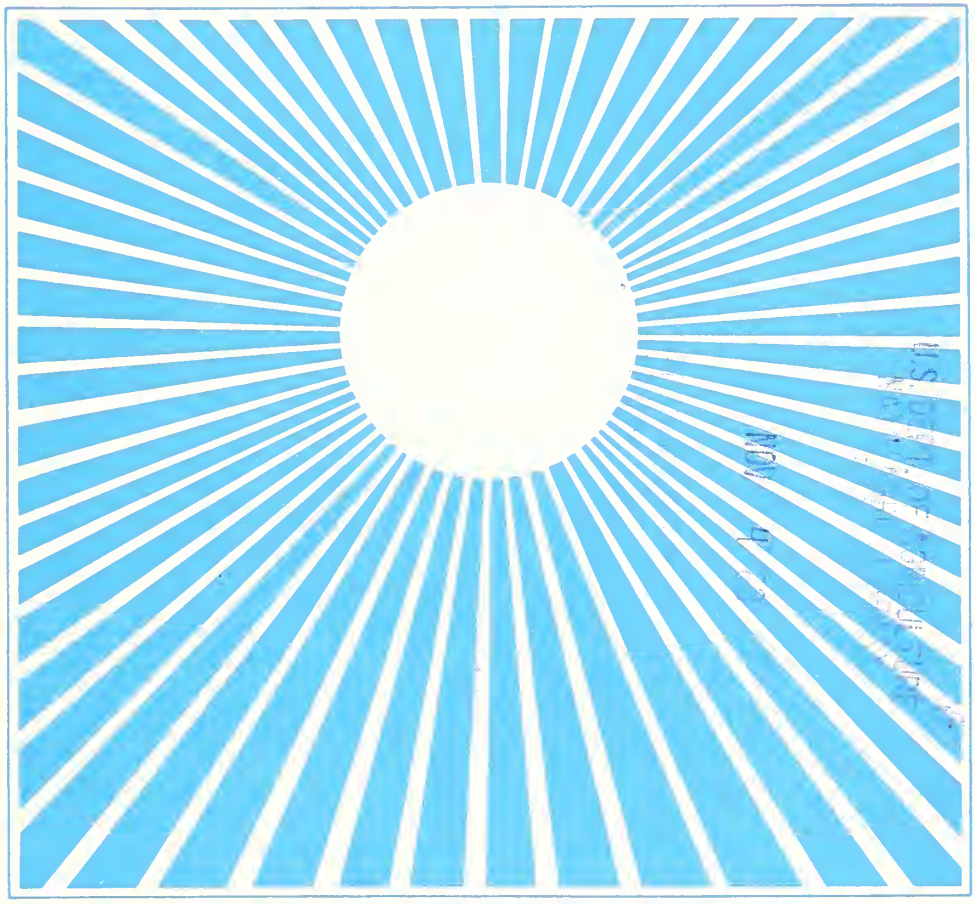
United States
Department of
Agriculture

Cooperative State
Research Service

Miscellaneous
Publication
Number 1435

Solar Energy and Nonfossil Fuel Research

A Directory of Projects Related to Agriculture 1981



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Solar Energy and Nonfossil Fuel Research

A Directory of Projects Related to Agriculture 1981

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for Cooperative State Research Service
U.S. Department of Agriculture

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PREFACE

This directory is the third in the series of annual compilations of solar energy and nonfossil fuel research projects related to agriculture. It was prepared by the Cooperative State Research Service, U.S. Department of Agriculture, in response to Title XIV, Subtitle H, of the Food and Agricultural Act of 1977 (P.L. 95-113). Section 1450 of the act requires the Department to prepare annually a compilation of research projects on this topic.

This publication lists 698 projects selected from the file of notices of research in progress registered with the Smithsonian Science Information Exchange (SSIE) as of October 1981, and maintained by the National Technical Information Service (NTIS). Projects included are those identified as active during the period from October 1980 to October 1981.

This directory updates the 1980 directory. It includes new and revised projects and more current progress reports for many of the projects contained in the earlier compilation. Projects which have remained active since 1980, regardless of any change in the project narratives, are also listed.

Except for minor editing, information appearing on each project was taken directly from project descriptions residing in the SSIE database. The Current Research Information System (CRIS), operated by the Cooperative State Research Service, U.S. Department of Agriculture, and the Department of Energy's Technical Information Center served as major sources for many of the projects listed here. Additional sources included other Federal agencies, State, private, and nonprofit institutions, and foreign organizations which provided project descriptions directly to SSIE.

Consistent with provisions of Section 1450 of the act, topics in this directory pertain to solar energy and nonfossil fuel research and its application to agriculture and the rural community. Studies related to farm operations, structures, and equipment, as well as farm dwellings, are included.

The arrangement of chapters within the Description of Research Projects section is patterned after the CRIS special classification for agricultural energy research and development. Specifically included are projects related to the development of technologies for use of alternate forms of energy (solar, wind, and geothermal), and those dealing with the substitution of critical sources of energy by renewable energy sources and forms (agricultural and forestry products and residues, energy farming, and biomass). Research on other nonfossil energy sources, primarily waste heat, and studies involving multiple sources of energy are listed in separate chapters. Considered out of scope for purposes of this directory were projects devoted solely to conservation and use of energy, noncritical sources, such as coal, lignite, oil shale, and peat, and consequences of energy production, availability, and use (reclamation, renovation, and environmental effects).

Latest progress reports on many ongoing projects listed here, as well as project descriptions of research on other agricultural energy topics, are available to personnel of the Department and cooperating State institutions through the CRIS retrieval service at USDA and to the public through the commercially available CRIS online file. For access and availability contact: Current Research Information System (CRIS), U.S. Department of Agriculture, National Agricultural Library Building, Beltsville, Maryland 20705.

CONTENTS

USER GUIDE

SAMPLE PROJECT DESCRIPTION

Directory Number — 4.0096
Chapter Number
Sequence within Chapter

Project Title — **ETHANOL FOR FUEL - PRODUCTION BY ZYMOMONAS**

Investigator(s), Performing Organization, and Address — *Chase T, Eveleigh DE, Montenecourt BS,* Dept. of Biochemistry & Microbiology, Rutgers University, *New Brunswick, New Jersey, 08903.*

Project, Grant, or Contract Number — (NJ01503)

Project Summary — OBJECTIVE: Simplify conversion of agricultural biomass (starch) to ethanol, a liquid transportation fuel, by constructing a hybrid bacterium, Zymomonae, able to degrade the starch and ferment it continuously to ethanol at a high temperature.
APPROACH: Thermotolerant Zymomonas strains will be selected. Fermentation conditions with starch-derived glucose syrup as substrate will be optimized. Levels of enzymes of the fermentation pathway will be determined. Zymomonas cells will be immobilized for continuous fermentation. Starch degrading pseudomonads will be hybridized with Zymomonas by conjugation, transformation with isolated DNA, or transformation via plasmid intermediates. Hybrids will be characterized with respect to stability, ethanol yields, and rate of starch degradation.
PROGRESS: Three Zymomonas strains were obtained, TCRP-1 from the American Type Culture Collection (#10988) and CP3 (var. recifensis) and AG-11 (Mexican) from Dr. Osvaldo Goncalves de Lima, University of Recife, Brazil. They showed the same growth rate at temperatures 30 to 36 degrees C (on 0.5% yeast extract - 2% glucose); cell yield decreases with increasing temperature. The doubling time is 2.5 hr at 36 degrees C. Cells transferred to tubes at 39 degrees C failed to grow; increasing temperature in one degree steps showed growth up through 37 degrees C. Overnight incubation at 39 degrees C in ethanol solutions (5% or higher) killed the cells, indicating that ethanol and high temperature may be synergistic in cell death and making high temperature fermentation more difficult. We have also obtained amylolytic strains of Pseudomonas for transfer of the amylase gene to Zymomonas.

Supporting Agency — SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

ARRANGEMENT OF ENTRIES

Projects in this publication are listed by chapter and are assigned unique identification numbers for locating project descriptions referenced in the indexes.

The DESCRIPTION OF RESEARCH PROJECTS section contains all project summaries alphabetically arranged within each chapter by State or country, city, performing organization, and investigator name. In line with this sequence each project is assigned a unique five-digit number (for example, 4.0096) indicating the chapter (left digit) and the position in the chapter (right four digits) in which the summary is located. A project which contains elements applicable to more than one chapter is placed in that chapter which best depicts the major energy component of the project, or in the chapter titled, Multiple Energy Sources.

The SUBJECT INDEX is based on a three-level, hierarchical indexing scheme in which specific terms are subsumed under those at the next higher generic level. "See" and "See Also" cross-references are included to assist in locating topics. Each index term to which a project is posted is followed by the project title and the unique five-digit number for locating the project summary, as in the following example:

ALCOHOLS
See Also Fuels

Ethanol
ETHANOL FOR FUEL - PRODUCTION BY ZYMOMONAS **4.0096**

For further assistance, the subject index is arranged in a dictionary format in which the first and last main headings on opposite pages also appear in the top margins.

The INVESTIGATOR INDEX is an alphabetical listing of all investigators cited on the projects.

The PERFORMING INSTITUTION INDEX lists the name and location of each institution where the research is conducted. Arrangement of entries is alphabetical by institution name within city and State or country. Institutions in the United States and its territories and possessions are listed first, followed by those in other countries.

DESCRIPTION OF RESEARCH PROJECTS

1. SOLAR ENERGY

1.0001
OPTIMIZE EFFICIENCY OF ENERGY UTILIZATION IN AGRICULTURAL HOUSING SYSTEMS
Koon JL, Dept. of Agricultural Engineering, Auburn University, *Auburn, Alabama, 36830,* (ALA00520)
OBJECTIVE: Increase efficiency of energy utilization in agricultural housing systems through development and evaluation of technological and management alternatives; develop energy-efficient design criteria for agricultural housing systems.
APPROACH: Major efforts will be directed toward utilization of solar energy in brooding of broiler chickens. Systems will be developed for both new construction and retrofit. Emphasis will be on the effect of the temperature and light environment on layers. Photoperiod responses to be investigated are effect on laying patterns, off-peak lighting for hens, and effect on shell quality. Temperature responses to be investigated are thyroid homeostasis, semen production, and thyroid-steroid interactions.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0002
HOUSING FOR LOW AND MODERATE INCOME FAMILIES
Boles WE, Dept. of Consumer Affairs, Auburn University, *Auburn, Alabama, 36830,* (ALA00510)
OBJECTIVE: Determine societal constraints to the adoption of housing alternatives, including those of finance, cost, regulations, policies, land use, and energy use. Determine constraints within the family to the adoption of housing alternatives including demographic characteristics, family resources, family decision-making processes, and consumer acceptance.
APPROACH: Sample households selected from non-SMSA counties stratified by median income and number of non-farm households. Personal interviews conducted with occupants of various types of housing will identify factors related to acceptance of selected housing forms and facilities; structural modifications which would improve quality or decrease cost of housing. Demographic characteristics, family resources, family decision-making procedures, factors influencing choices, and energy consumption patterns will be ascertained.
PROGRESS: Preliminary data of user based evaluation of residential solar water heating indicate that most users are highly knowledgeable of their solar units and many either directed or participated in the installation. However, a surprising number of owners possess little knowledge of their solar system. Data yet to be analyzed include: (1) consumer decision making, (2) manufacturers' and sales claims, (3) ease of installation, (4) maintenance and warranty knowledge, and (5) performance characteristics.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0003
INTEGRATION OF A SOLAR GREENHOUSE WITH A RECIRCULATING FISH CULTURE SYSTEM
Allison R, Dept. of Fisheries & Allied Aquacultures, Auburn University, *Auburn, Alabama, 36860,* (ALA00527)
OBJECTIVE: Determine the operational characteristics of a solar heated greenhouse, thermal storage and heat recovery facility for fish culture. Evaluate a recirculating fish culture system compatible with the greenhouse, thermal storage and heat recovery facility. Develop design and cost information based on the above to enable full scale production system to be built.
APPROACH: Food fish populations will be grown in tanks. The effluent will be reconditioned by circulation through a clarifier and tanks containing aquatic macrophytes. Reconditioned water will be aerated and returned to the food fish production tanks. The fish culture units will be housed in a solar heated greenhouse. The greenhouse will contain a heat storage facility and a heat recovery system.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0004
POTENTIAL FOR CONVERSION AND UTILIZATION OF SOLAR ENERGY IN POULTRY PRODUCTION
Brewer RN, Flood CA, White M, Dept. of Poultry Science, Auburn University, *Auburn, Alabama, 36830,* (ALA-50-0056)
OBJECTIVE: Determine amount and types of fuel used in production of poultry products, and probe feasibility of replacing part or all of this energy requirement with solar energy.
APPROACH: Fuel use data will be collected from commercial poultry firms throughout the country. Broilers, layers, turkeys, ducks, and other poultry will be included in the survey. Projected supply and demand for this fuel will be integrated with current and future poultry production expectations to show the critical nature of energy supply for poultry production. Preliminary modeling of production units using available energy and environmental data will be used to predict potential for solar utilization.
PROGRESS: Two experiments were conducted testing the efficiency of single glazed vertical wall collectors and forced air convection in heating the research pens. The two systems saved as much as 45% of total heat required to brood broilers reared during February and March. Of the two, the verticle wall collectors allowed approximately three times as much savings. The forced air convection allowed heat exchange at lower storage water temperature, but made only minor contributions as long as ample solar energy was available. The combined systems allowed birds to be brooded for $12.50 per thousand while the systems not using vertical wall collectors cost $18.50 per thousand. This system will be tested further. A new rock storage solar collection and storage system has been constructed, using materials available locally. This system will be compared to the water storage system now being used. It is expected that the rock system will be more cost effective and equally effective as a heat source. A vertical wall, solid storage system is also being constructed. This system approximates the present vertical wall system, but adds limited storage. The concrete block storage wall will also be used as an evaporative cooler in summer months.
SUPPORTED BY: Alabama State Government.

1.0005
ANNUAL CYCLE SOLAR REGENERATION OF DESICCANT FOR CROP DRYING
Fletcher JW, Butler JL, Lockheed Missiles & Space Co. Inc., *Huntsville, Alabama, 35807,* (7004-20190-016-G(1))
OBJECTIVE: Evaluate the performance of the solar regenerated desiccant pond concept and determine its technical feasibility and practicality. Additional objectives are to assess the economic potential of the concept and develop design criteria for a prototype system.
APPROACH: A system analysis will be performed on the proposed solar drying system to define the design conditions for the crop drying and regeneration system. Following this an experimental version will be designed, constructed and evaluated. The analysis of these tests will include an economic feasibility study and a plan for commercialization.
PROGRESS: A desiccant container 5 meters long, 1.7 meters wide and 0.9 meters deep containing approximately 9072 kg of 35% CaCl(2) solution was constructed. The cylindrical wheel collector-absorber is 4.9 meters long, 1.5 meters dia. with a 5 cm thick absorber mat. This system is to use solar energy on an annual cycle to regenerate the CaCl(2) for crop drying. The design drying capacity is 136 kg per hour. Due to delay in funding, the system was not made operational until October. 1360 kg of soybeans were dried from 14% to 8% in 10 hours using a 38% solution of CaCl(2). Following drying, the regeneration cycle was begun for the 1979 crop drying season.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0006
CULTURE SYSTEMS AND SPECIES REQUIREMENTS FOR FISH IN RESEARCH AND PRODUCTION
Parker NC, Southeastern Fish Culture Lab U.S. Dept. of the Interior, Fish & Wildlife Service, *Marion, Alabama, 36756,* (85450-968-52)
OBJECTIVE: To develop guidelines for propagating largemouth bass and other priority warm-water fishes, i.e., develop or improve spawning and rearing methods; artificial diets for fry, fingerlings, and broodstock; stamina and losses in transport, stocking, and angling returns; guidelines for using chemical treatments in culture; foodstock for production strains. Current studies are of environmental systems design for fish in research and production; endocrine function in reproduction, growth, and morphogenesis; criteria for screening species for tank and raceway production. Progress on environmental control includes installation of a fish culture system with low energy requirements for pumping, filtration, and thermal control. This system will be operated throughout the year to produce fish in a controlled environment. Species environmental and physiological requirements for optimum growth, production, maturation, and spawning will be evaluated. Reponses to chronic stresses i.e., stocking density, low DO, NH(3), etc., associated with intensive culture will be monitored and related to species performance when subjected to acute stresses. To achieve maximum thermal stabilization, fish tanks have been placed in the ground with the water level below ground surface. With an inflow of well water at 19 degrees C and with soil temperature remaining nearly constant, the resulting water temperature in the culture system is expected to be ideal for striped bass production throughout the year. For production of warm-water species the system will be heated by using solar collectors and the water surfaces will be protected from the cold weather by domed covers. Water-reuse will be achieved by using rotating biological disc filters and tube clarification to maintain water quality at acceptable levels for fish production.
SUPPORTED BY: U.S. Dept. of the Interior.

1.0007
UTILIZATION OF ALTERNATE ENERGY SOURCES IN ALASKA
Allen LD, Inst. of Agricultural Sciences, University of Alaska, *Palmer, Alaska, 99645,* (ALK-79-06)
OBJECTIVE: Investigate the availability and use of renewable energy sources in Alaska. Consider the most useful alternate energy applications for Alaska's high latitude and determine the cost or savings for specific alternate energy applications, evaluate energy efficient structures alone or in combination with alternate energy sources as a means of reducing the conventional energy requirement in Alaska agriculture.
APPROACH: Portable weather observation equipment will be assembled to evaluate weather

parameters at specific sites of interest, and will to be used to assess differences in weather events that may vary over short distance, i.e., local winds. Local structures will be modified or adapted to improve energy efficiency. Solar assisted grain drying will be evaluated by the construction of similar 1000 bushel bins, one fitted with a solar collector. Air flow, electric power use, drying rates, grain quality, and other factors will be monitored. Existing structures will be modified or fitted with energy saving or solar collecting devices, and the results monitored.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0008
MECHANISMS OF PHOTOCHEMICAL ENERGY CONVERSION BY CHLOROPHYLL
Tollin GA, Dept. of Biochemistry, University of Arizona, *Tucson, Arizona, 85721,* (AC02-78ER04927)
OBJECTIVE: The excited state dynamics and the yields and lifetimes of radicals are being investigated in systems containing chlorophyll and electron acceptors dissolved in lipid bilayers or polymer films. Laser photolysis and electron spin resonance are being used in these studies. The proposed work involves the effects of variations in the lipid composition of the bilayers, especially as related to viscosity and surface charge, the use of quinone polymers as media, the effect of variations in acceptor structure and redox potential, and variations in donor properties (e.g., use of pheophytin or bacteriochlorophyll in place of or in addition to chlorophyll). Particular emphasis is being placed upon developing strategies to increase radical yields and lifetimes with a view towards the possible construction of solar energy conversion systems. We have determined the kinetics of chlorophyll triplet state quenching by quinones in both polymer films and liposomes. We have also measured radical yields in these systems. The results indicate that there are two mechanisms for radical production and decay in the liposome, one of which is intra-bilayer and the other of which is trans-bilayer. The latter decay is approximately 10/sup 3/ times slower than the former.
SUPPORTED BY: U.S. Dept. of Energy, Office of Energy Research.

1.0009
FRUIT DEHYDRATION USING GREENHOUSE STRUCTURES
Price RL, Berry RE, Dept. of Nutrition & Food Science, University of Arizona, *Tucson, Arizona, 15721,* (7004-20510-020A(1))
OBJECTIVE: Determine feasibility of using greenhouse structures in hot, dry climates for dehydration of fruits and vegetables. Determine fruit and vegetable cultivars best compatible for this type drying. Recommend most suitable structures as drying systems.
APPROACH: Compare, prepare and select fruits and vegetables for dehydration in three structures: horizontal and vertical air-flow greenhouses and a soil desiccant cold frame. Compare with conventionally dried products using forced air oven. Compare operation in different temperatures and relative humidities. Compare dried products chemically and organoleptically for nutritional content, general quality and consumer preference. Derive computer simulation model based on experimental measurements, to predict applicability of results to other regions.
PROGRESS: Sliced apples, peaches and apricots from several fruit cultivars have been dried in greenhouse type structures of three different configurations: horizontal air flow, vertical air flow and a soil desiccant cold frame. A conventional forced air oven has been used to dry products as a reference. Products prepared during climatic periods varying from warm and arid to hot and humid, are being compared for quality, nutrition and storage stability.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0010
ADDING MARKET VALUE TO HARVESTED ARIZONA VEGETABLES AND GRAIN BY PROCESSING WITH SOLAR ENERGY
Foster RE. Dept. of Plant Sciences, University of Arizona, *Tucson, Arizona, 85721,* (ARZT-172381-56-14)
OBJECTIVE: Utilize surplus vegetables by dehydrating "completely." Improve shipping ability of Arizona vegetables and reduce transit costs and handling losses by removing small amounts of moisture at origin and restoring it at destination. Permit early grain harvest by artificially drying immature grain. Accomplish all of above through use of solar energy.
APPROACH: Use fossil fuel to simulate solar powered dehydrator. Establish machine requirements and develop methods. Obtain harvested produce, apply drying treatments, store, restore to original form, evaluate by appropriate comparisons. Compare artificially dried grain with full term grain. Determine proper timing by comparing different ages.
PROGRESS: Most of the activity in this project centered around broccoli as a representative of the green leafy winter type of produce and muskmelon which is one of the most important summer crops. Neither crop responded well to complete dehydration and subsequent attempts to restore moisture to a completely palatable state. Both crops, however, were made potentially more valuable by partial drying and the concomitant reduction in shipping weight. Broccoli weight could be reduced by as much as 19% without loss in restored quality. It was difficult to reduce muskmelon weight by more than 6% but for both crops freight costs and energy use could be reduced substantially. Whereas no adverse conditions were encountered for the green vegetable, a surprising and vexing problem appeared with the partially dried melons. In storage, treated cantaloupes developed more surface mold (mostly Botrytis and Aspergillus) than non-dried counterpart fruit. It is apparent that some fungicidal treatment would have to accompany partial drying for complete success. Rehydration is accomplished more readily when a surfactant is used. Materials of this sort remove most of the "bloom" from broccoli surfaces resulting in a brighter, attractive green color but otherwise unchanged. Removing bloom before dehydration reduces treatment time significantly for several vegetables and has no adverse effect upon storage or rehydration.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0011
SOLAR ENGERY UTILIZATION IN DAIRIES
Wiersma F, Winter DW, Dept. of Soils Water & Engineering, University of Arizona, *Tucson, Arizona, 85721,* (7092-20401-012A(3))
OBJECTIVE: Develop design criteria for use of solar energy for heating and cooling needs in dairy facilities in various climatic regions, develop a computer simulation model for evaluation of solar energy systems for dairies, and determine economic feasibility of use of solar energy systems for dairies.
APPROACH: Basic design parameters developed by ARS-USDA at Beltsville, MD, for use of solar energy in milking phase of dairy production, will be adapted to various climatic conditions, with emphasis on desert climates of Southwest. A computer simulation model will be developed to facilitate evaluation, including economic feasibility of solar energy systems in dairies. Plans will be prepared for use of solar energy in a research dairy in Arizona for verification of studies.
PROGRESS: Hot water use on dairies of various sizes and types has been quantified. Use varies primarily with management practices and herd size. Average use is substantially in excess of needs calculated on the basis of frugal use and minimum energy loss. A performance test on a unit for heating water with milk cooling system refrigerant gas proved positive but with modest benefits. Energy losses from stored hot water reduce the benefit below full potential. Additionally, unless the refrigeration system includes water heating as a design criterion, refrigerant temperatures are too low to heat water to temperatures required for parlor use. With the warm source water in the geographical area in which the tests were conducted and the modest temperatures to which the water was heated, the water temperature rise in the heat recovery unit is only about 25 degrees C. These benefit limitations are essentially the same as exists with the solar water heating system. Preliminary tests on a precooling system utilizing an evaporative air cooler to remove the first heat from milk show excellent results. The cooler is two-stage, cooling potable water in closed coils cooled by forced air and cascading water. The potable water and milk are circulated through a tube cooler.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0012
ENERGY CONSERVATION ALTERNATIVES FOR ARKANSAS RURAL RESIDENCES
Magee C, Redfern JM, Rokeby TR, Dept. of Agricultural Engineering, University of Arkansas *Fayetteville, Arkansas, 72701,* (ARK00841)
OBJECTIVE: Develop, evaluate and optimize methods of energy conservation for Arkansas residences. Evaluate and develop systems for use and control of alternative energy sources, principally solar, for heating rural residences.
APPROACH: Apply a dynamic mathematical model of typical Arkansas residences to predict thermal performance, including energy comsumption. Use the model to select optimum energy conservation practices for Arkansas residences. Verify predicted performance by observation of actual residences incorporating such conservation methods. Apply the model to predict performance of solar heating systems for Arkansas residences and validate by observation of two or more solar heated residences to be constructed. Determine fuel and power consumption, construction and operating costs of solar heated residences and compare with conventional residences.
PROGRESS: A new faculty member has been added in Agricultural Engineering. New research priorities have been set that relate to this project and it will be revised by 30 June 1980.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0013
BROODING CHICKS WITH SOLAR ENERGY
Rokeby TR, Redfern JM, Harris GC, Dept. of Agricultural Engineering, University of Arkansas, *Fayetteville, Arkansas, 72701,* (ARK00923)
OBJECTIVE: Develop systems and operating methods for using solar heat to brood chickens, with emphasis on retrofitting existing buildings. Develop systems and methods for conserving heat energy in brooding chickens. Evaluate the physical and biological performance of the proposed conservation measures and solar heating systems. Determine the economic feasibility of using solar heating and conservation measures for brooding chickens.
APPROACH: Weather and environmental conditions and energy flows in a solar heated commercial broiler house will be studied. Biological performance, including mortality, weights and feed conversion will be monitored. Economic factors, including returns from a standard grower contract, will be determined. Resulting data will be used as a base for improved designs, economic analyses and computer modeling of energy management systems.
PROGRESS: Five flocks of 8800 broiler chickens each were raised in the solar house during 1979. Records of bird performance and solar heating system performance were obtained. A new, more adequate data acquisition system was installed during the summer. Bird performance data was obtained from a large number of commercial flocks for comparison purposes. Birds from the first ten flocks from the solar house have averaged 0.66 kg heavier, with feed conversion .06 better, livability .89% higher but with a .78% worse condemnation rate. As compared to a group of local commercial houses, the solar house saved 66% of the purchased fuel for the three flocks between October 1978 and November 1979. Half of this saving resulted from solar heating and the remainder was by the energy conserving features built into the house, which included half-house brooding, narrow curtains, improved insulation and sealing, and more precise control methods. For the research evalua-

tion figures were adjusted to a 16,000 bird house, the industry norm. The investment cost that the University would have paid for a 16,000-bird broiler house was $55,000. Using straight line depreciation, 20 years of life, zero salvage value, and taxes equal to one half percent of the initial cost, the estimated annual operating cost would be $5,689.
SUPPORTED BY: Arkansas State Government.

1.0014
ENERGY REDUCTION FOR ON-FARM PROCESSING OF AGRICULTURAL PRODUCTS
Warnock WK, Dept. of Agricultural Engineering, University of Arkansas, *Fayetteville, Arkansas, 72701*, (ARKF-1025)
OBJECTIVE: Determine energy consumption of various harvesting, processing, and storage systems. Reduce or substitute fossil fuel required in existing systems for processing agricultural crops.
APPROACH: Data will be obtained to derive input energy for conventional on-farm drying and storage for rice and grain sorghum. The energy efficiency and effectiveness of on-farm drying and storage systems for rice and grain sorghum will be investigated and emphasis will be made on the application of techniques and practices to increase the energy efficiency. Air-type flat plate solar collectors will be incorporated into a low temperature conventional electric drying system and compared to a conventional low temperature drying system. The electrical portion of the solar/electric system will be operated during off-peak hours.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0015
SOLAR HEATED SEPTIC TANKS FOR DEAD POULTRY DISPOSAL
Warnock WK, Mote CR, Halbrook W, Dept. of Agricultural Engineering, University of Arkansas, *Fayetteville, Arkansas, 72701* (ARK00935)
OBJECTIVE: Demonstrate the use of septic tank-filter field systems for poultry disposal. Demonstrate the effects of heating and agitation on the efficiency of septic tanks for poultry disposal. Investigate overall energy efficiency of solar heated septic tanks. Investigate the economic incentives for using heated septic tank-filter field systems for dead poultry disposal.
APPROACH: Two solar heated septic tank systems with one control system will be located on the University of Arkansas Main Experiment Station, Fayetteville, Arkansas. Water samples will be collected monthly from each septic tank's effluent and from two well points installed below each filter field. Water samples will be analyzed for concentration of total solids, suspended solids, volatile solids, etc. Two solar collector systems will maintain optimum biological temperatures in the septic tanks. The relative economics of heated septic tank systems for dead chicken disposal will be determined by comparing the construction and operating costs of the research units with other disposal methods.
PROGRESS: Three septic tanks have been installed and the two heated tanks are currently operating at 35 degrees C. Hot water is presently supplied by electric water heaters, but the solar units will be in operation within the early part of this year. Data are being collected on the effluent and water in the septic tanks. Also, tank temperatures and water usage are being monitored.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0016
ASSESSMENT OF TECHNOLOGY IN THE FOOD AND FIBER SYSTEM
Miller ME, U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Div., U.S. Dept. of Agriculture, *Albany, California, 94710*, (NEA-12-107-06-02)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra- and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Solar energy applications research continued with data gathering and consulting with SEA/AR and SAES engineers. The major applications were tobacco irrigation, peanut drying, and greenhouse heating. Solar powered irrigation was also studied but not as intensely as the other areas. The feasibility of feeding crop residues to beef cattle was studied. The study inventoried residues on a county-by-county basis, estimated the economic values of residues, and identified the economic effects of reducing grains and increasing forage and residues. Data were gathered to compare trends in technology and productivity in processing and distribution. Uses of agricultural products in manufactured goods were identified.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

1.0017
SOLAR AND OSMOTIC DRYING SYSTEMS TO REDUCE ENERGY USE IN FOOD PROCESSING AND HANDLING
Bolin H, Huxsoll C, Western Regional Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Albany, California, 94710*, (5102-20510-002)
OBJECTIVE: Reduce the requirements of fossil-fuel energy for processing, storage and transportation of fruit and vegetable commodities.
APPROACH: Methods of dehydrating piece-form foods using systems that require less fossil fuel than conventional dryers will be studied. Specifically, osmotic drying systems in which the syrups, or brines, may be reconcentrated in multiple-effect evaporators will be examined. Low cost solar collectors, such as inflated plastic tubes, will be designed and studied in conjunction with systems for mechanically harvesting and handling to enhance on-farm processing of some crops. Basic information on absorptivity of drying fruit will also be obtained. Solar dryers that are easy to construct and operate will be designed for use in small farm operations.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0018
1980 SUMMER STUDY ON BUILDING ENERGY EFFICIENCY
Morgan S, American Council for an Energy Efficient Economy, *Berkeley, California, 94720*, (XE 0 9321 01)
OBJECTIVE: The objective is to bring together some of the leading researchers and practitioners in building energy efficiency and renewable resource use to assemble, discuss, and develop up-to-date written materials which will be compiled into one or more volumes that adequately cover all elements of efficiency use of energy in buildings. The purpose of the volume(s) is information transfer.
APPROACH: Component draft materials on the technical, economic, and institutional factors of building energy use will be developed by intensive sessions of individual expert groups working over a two-week period, and subject integration will be achieved by inter-group sessions and plenary discussions of draft materials, which will also include the participation of additional experts from government, industry and universities. The publications will serve the needs of researchers interested in developing technology, private firms interested in marketing energy products, policy makers and legislators. The topics to be discussed include: (1) existing residential buildings (solar retrofits, technical approaches and economics of retrofits, research and demonstration needs, pilot programs, residential building appliances, foreign experience); (2) new residential buildings (architecture, solar applications, energy performance standards, residential appliances); (3) existing commercial buildings (retrofits, pilot programs, HVAC), and (4) new commercial buildings (architecture, lighting and daylighting, HVAC, thermal storage and solar applications, energy performance standards).
SUPPORTED BY: U.S. Dept. of Energy.

1.0019
LANDSCAPE PERCEPTION AS AN INPUT TO OPEN SPACE PLANNING
Thayer RL, Hodgson RW, Dept. of Environmental Horticulture, University of California, *Davis, California, 95616*, (CA-D#-EHT-333-H)
OBJECTIVE: Analyze how user perception of regional open space can be integrated into the planning, design, and management process.
APPROACH: Analysis of past and current research in landscape perception with particular emphasis on methods and applications followed by original experimentation and field research. Specific data shall be sought as to the aesthetic and experiential qualities of stream and river drainages, wildland fragments in urban and rural areas, and semi-remote recreation sites in an attempt to recognize and predict trends, preferences, likes and dislikes. Emphasis will be placed on passive recreation activities directly relating to natural environments. Evaluation and implementation of research conclusions in the form of a pilot project of open space planning.
PROGRESS: Progress was made on the Slossen Grant to examine human response to drought-stressed plants. Eight test landscapes were constructed and the response questionnaire designed. An experiment was conducted examining children's preferences for certain play environments in an elementary school yard in Davis, California. Results indicate that hard-surfaced materials receive more use than soft, and that boys and girls use different portions of the play yard. A follow-experiment was designed and run which investigates children's preferences for height, enclosure, and material in a model playground. Data were collected for two age groups (5-6 years and 11-12 years), three populations (rural, suburban, and urban), and both sexes. Analysis is pending funding. Several papers and a case study analysis were completed discussing theories of human response to solar architecture and energy-saving design in residential environments. A case study was completed on People's Park, Berkeley, which (among other things) discussed the political symbolism of an open space.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0020
SOLAR PRODUCTION OF STEAM FOR FOOD PROCESSING
Cherne JM, Energy Systems Group, Thompson Ramo Wooldridge Inc., *Redondo Beach, California, 90278*, (97235)
OBJECTIVE: The project is to design, build, operate and evaluate a solar system steam generating system.
APPROACH: Concentrating solar collectors will be used to collect heat which will be transferred to a steam generator where steam will be produced and delivered to a potato fryer heat exchanger. The solar generated steam will supplement steam generated by a fossil fuel boiler which also supplies other fryers to be used for comparison.
PROGRESS: System analysis and design have been completed, all mechanical and electrical work is almost complete. Installation of the system is underway. Control system and programming is complete.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

1.0021
APPLICATION OF SOLAR ENERGY TO INDUSTRIAL DEHYDRATION LAMANUZZI AND PANTALEO DEHYDRATION FACILITY
Carnegie EJ, Dept. of Agricultural Engineering, California Polytechnic State University, *San Luis Obispo, California, 93407*, (726)
OBJECTIVE: California Polytechnic State University Foundation will upgrade various components of

the solar industrial process heat system at the Lamanuzzi and Pantaleo Dehydration Facility in Fresno, California, including redesign and replacement of glazing on 30 solar collectors and modification of the present control system. During the drying season, the solar hot air dehydration system will be monitored and evaluated while in operation, and the data will be documented in a final report.
SUPPORTED BY: U.S. Dept. of Energy.

1.0022
FLORICULTURE INVESTIGATIONS
Hanan JJ, Goldsberry KL, Hartley DE, Agricultural Experiment Station, Colorado State University, *Fort Collins, Colorado, 80523,* (COL00047)
OBJECTIVE: Investigate the culture and handling of cut flower, foliage and bedding and pot plant crops grown in protected horticulture. This includes: investigating new methods of culture and conducting research on plant physiology to improve cultural procedures; examining methods to reduce raw material requirements of water and energy; and testing materials and systems in greenhouse design, and new methods of automation.
APPROACH: Areas of research are to: test new methods of irrigation, and systems to reduce water consumption; determine heat consumption of various greenhouse designs, methods and systems to utilize solar energy, conserve heat, and increase efficiency of raw material input; define physical characteristics of soils and soil mixtures as applicable to greenhouse culture; investigate salinity problems and fertilization programs to reduce fertilizer consumption; maintain a continuous selection program for outstanding carnation clones with higher quality and productivity; and test systems for timing production and increasing quality.
PROGRESS: Three standard carnations (d. Carophyllus) cultivars, CSU Red, Elliott's White, and Nora were grown in four greenhouses covered with three and eleven-year old fiberglass reinforced plastic (FRP) panels and single and double 6 mil polyethylene respectively. Flower production was correlated with insolation created by the covers. The first year's data showed that 410 flrs/m (2) were produced under the single poly cover and 400; 380 and 280/m (2) under the three-year old FRP, double poly and 11-year old FRP, respectively. The poorest quality was in the single poly covered house. The yields of three miniature carnation varieties grown in the same four houses responded similarly. During the winter months the three-year old FRP cover transmitted more radiation than the single (due to condensation present) or the double poly covers. Herbicides of 2, 4-D amine, Dicamba and various combinations and concentrations thereof were sprayed on d. carophyllus cultivar white number one, before and after pinches were made. Most concentrations and/or combinations contributed to epinasty, split nodes, callus formation and adventitious roots at the base of the plants and in some instances short internodes. The responses are being documented for possible future contamination problems.
SUPPORTED BY: Colorado State Government.

1.0023
DEVELOPMENT AND DEMONSTRATION OF SOLAR MALT KILNING
Smith CC, Berry RE, Dept. of Civil Engineering, Colorado State University, *Fort Collins, Colorado, 80523,* (7002-20520-001-A)
OBJECTIVE: Determine range of malt kilning most compatible with solar energy usage and best operating system of kilning to take optimum advantage of solar energy and minimize usage of conventional fossil-derived energy.
APPROACH: Design solar malt kiln. Operate comparing direct solar supply with auxiliary back-up. Heat storage in pebble bed for night operation, Two-day kilning with malt held overnight. Compare final product quality of solar kilned malt with conventionally kilned malt. Recommend optimum operating system for lowest cost and minimum energy usage.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0024
SOLAR HEATING OF GREENHOUSES COMBINED WITH SPACE HEATED BUILDINGS
Smith CC, Butler JL, Dept. of Civil Engineering, Colorado State University, *Fort Collins, Colorado, 80523,* (7093-20691-013-A)
OBJECTIVE: Develop, test, and demonstrate solar heating of an operational greenhouse combined with a space-heated building.
APPROACH: Design a double-layer glass greenhouse, heat storage, and solar collectors to provide an efficient integrated arrangement of these three solar components with an existing building so that solar heat collected by the greenhouse and collectors will supply about 75 percent of the heating requirements of both the building and greenhouse in Colorado. The building has 800 ft , the greenhouse will have a floor area of 800 ft and the collector will be about 700 ft in area. The components will be constructed and the entire system will be instrumented for tests during a winter heating season.
PROGRESS: A solar heated greenhouse-residence combination has been operated and evaluated since December 1976. In addition to space heating, the solar system heats water used to heat the greenhouse growing medium. This allows greenhouse space temperature to be reduced to conserve energy. Two types of night insolation were installed in the greenhouse, one uses a polystyrene bead system, and the other a commercially available night curtain system. Solar energy can be usefully collected for irrigation water heating even when insolation rates are too low for collection and storage for space heating. During the period March 23 through April 30, 1978, the solar system delivered 0.45 multiplied by 10 to the 6 Btu for house heat and 1.68 multiplied by 10 to the 6 Btu to the greenhouse via soil and irrigation water heating. During this same period no auxiliary space heat was needed by the greenhouse or residence.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0025
COLO. TITLE V RURAL DEVELOPMENT DEMONSTRATION PROJECT
Newlin JT, Dept. of Education, Colorado State University, *Fort Collins, Colorado, 80523,* (COL04770)
OBJECTIVE: The revitalization of rural areas and rural communities. Assist local communities directed toward opportunities for people to become stronger and more capable human beings with options as to one's work and one's place of residence with an enhanced capacity to play a part in making decisions affecting one's community.
APPROACH: Facilitate the delivery of resources in support of rural development activities by means of workshops, seminars, conferences, development of information media and documentation of research needs.
PROGRESS: 1. Rural Teaching Project. Phase II of the project is completed. Data were being analyzed and final report was in process of being published in 1979. Rural teaching experiences were provided nearly 150 students in 1978 assigned to teach for one week in 10 rural Colorado communities. Evaluations showed a significant increase in positive attitudes toward living and teaching in rural communities. Four student teachers were placed in rural schools for ten week teaching internships. One hundred (smallest) rural school district teachers were surveyed to determine perceived in-service training needs and personal concerns. Also, a sample was drawn from administrators, principals and board members. 2. Evaluation of Low Cost Solar Domestic Heating Systems (Self-Help Housing). The evaluation identifies problem areas in the technical performance of solar walls. As a result, a solar wall maintenance manual was prepared to serve as an instructional manual for a series of workshops with self-help housing project clientele and other energy conservation workshops. Special funds were provided by the Colorado Rural Housing Development Corporation (CRHDC) for funding a CSU graduate research assistant to work with CRHDC in conducting the energy conservation workshops. Extension Title V project leader was appointed to the CRHDC Board of Directors. 3. Ground Water Recharge. Frenchman Creek Watershed Project spin-off.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0026
LOW COST SOLAR COLLECTION AND STORAGE SYSTEM FOR SUPPLEMENTAL HEATING OF BROILER HOUSES
Collins NE, Handy WE, Walpole EW, Dept. of Agricultural Engineering, University of Delaware, *Newark, Delaware, 19711,* (DEL00187)
OBJECTIVE: Determine performance of horizontal plastic solar collectors using water as the collecting and storage medium. Develop a computer simulation to optimize the utilization of solar heating and evaluate a pilot model.
APPROACH: Flat tube collectors and storage ponds of varying sizes and amounts of insulation will be evaluated for efficiency as heat collectors. Data to be recorded will include solar radiation (measured with Fritschen net radiometer), ambient air dry bulb and dew point temperatures, collector temperatures and the temperature gradient below the collector. All temperature data will be measured and recorded on magnetic tape by a 40 channel thermocouple reporting system. The computer simulation will consider the available solar radiation, collector and storage design, sizes, efficiencies, cost and predicted supplemental heating load. A prototype of the optimum solar heating system for a broiler house will be constructed and tested to verify the computer simulation for field applications.
PROGRESS: The computer simulation of on-farm broiler production has been expanded to estimate 1) solar energy collection using cloud cover data and 2) the cost of solar brooding systems. The physiological model of the broiler has been modified to simulate the growth of a flock. This was accomplished by dividing the population into males and females and then further subdividing the sexes by weight groups. By subdividing the flock, mortality during heat stress can be studied. The physiological model is now being used to study pullet performance on "skip-a-day" or "limited-every-day" feeding programs. The performance of cylindrical, line-concentrating pressure-stabilized solar collector with an east-west orientation has been studied. Field test indicated that 1) the arc length of the collector surface should be limited to 80 degrees (measured from top), 2) a vapor barrier is needed under the collector to prevent condensation and, 3) boiling in the absorber tube can be a problem. The plan of work for next year includes a) construction of solar brooding system for a broiler house with a 5000 bird capacity, b) developing a 25-year weather data base, c) study infiltration and effects on heat load, d) improve physiological model of broiler, and e) model ammonia cycle.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0027
THE USE OF A CONCENTRATING SOLAR COLLECTOR FOR HEATING AND COOLING OF BROILER HOUSES
Collins NE, Winter DW, Dept. of Agricultural Engineering, University of Delaware, *Newark, Delaware, 19711,* (7004-20400-016-A)
OBJECTIVE: Construct and operate a prototype solar heating system for broiler houses utilizing a cylindrical, line-concentrating, pressure-stabilized solar collector and investigate the economic feasibility of solar cooling during the summer months.
APPROACH: Retrofit broiler house for limited area brooding; install solar and data collection system; obtain data from chick traits; use computer simulation to refine system and to study summer cooling.
PROGRESS: The final drawings and bidding documents are being prepared for the solar brooding system to be installed at the Georgetown Substation. Based on tests with a 175 sq. ft. prototype, the following features are incorporated in the design of the cylindrical line-concentrating, pressure-stabilized solar collector: a) arc length of collector limited to 80 degrees, b) vapor barrier between soil and collector, c) glass covering on absorber tube, d) copper absorber tube and e) closed loop with high-temperature heat collection fluid. A

hot water storage tank located in the corner of the house will be used as the heat exchanger. Rapid increases in the cost of collector materials are making it more difficult to demonstrate the potential economic feasibility. A simplistic model of collector performance has been developed utilizing total sky cover to estimate energy collection. Simulation results indicate that collector and storage capacities must be carefully matched to the facility. In other modeling studies, it has been found that a) dehumidification of ventilation air is not cost effective and b) to control ammonia by dilution (overventilation) in warm room brooded houses requires an additional 12 to 16 gallons of LP gas/1000 birds.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0028
ENERGY USE AND CONSERVATION IN U.S. AGRICULTURE
Devlin P, Barton J, Lutton T, National Economic Div., U.S. Dept of Agriculture, Economics & Statistics Service, *Washington, District of Columbia, 20250,* (NEA-21-135-11-00)
OBJECTIVE: Develop, maintain, and project statistics of energy use on farms including direct fuel use such as gasoline, diesel, LPG and electricity and indirect or embodied energy in inputs such as natural gas in fertilizers, pesticides, and Btu in machinery and equipment. Determine the potential for conservation of energy use in farm production. Determine the impact of changes in energy prices on use on farms, production patterns, adoption of energy saving technology, and cost and returns to farmers by regions and States.
APPROACH: Develop monthly estimates of farm production needs for energy by construction of energy consumption budgets for major commodities by State and region. Evaluate economic, environmental, and technical feasibility of selected energy conservation measures and new technologies and estimate their conservation potentials. Project farm energy needs by periods to 1990 under several different price and conservation policy scenarios.
PROGRESS: Energy information in the Agricultural Data Base was revised and updated from 1974 to 1978. Weekly reports on gasoline and diesel fuel supplies were prepared as a guide in fuel allocation during the Summer and Fall of 1979. A time series data base for food processing industries was developed at the 3-digit SIC level and a model of the 3-digit food processing industries was prepared to analyze changes in fuel consumption as a result of changes in energy prices. Estimates of energy used in transportation were prepared and published. Evaluation of the potential of solar energy in agriculture was carried out in cooperation with the Science and Education Administration.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

1.0029
SOLAR ENERGY CONVERSION AS APPLIED TO GREENHOUSES
Waters WE, Clements WR, Agricultural Research & Education Center, University of Florida, *Bradenton, Florida, 33505,* (FLA-GC-01793)
OBJECTIVE: Design, construct and install a practical, moderate temperature solar energy conversion device to heat air; couple this device with heat storage systems suitable for greenhouse application; offer results of this research to the general public with emphasis on attracting manufacturers willing to construct such systems for greenhouse industry.
APPROACH: Construct varying quantities of each collector design (3 designs); construct inexpensive rock storage containers of varying designs; design, install these devices and a ducting and control system in a glass greenhouse at the Bradenton Agricultural Research Center; incorporate testing devices in said greenhouses to refine operation and equipment design.
PROGRESS: Research continued on application of solar energy relative to space heating of greenhouses by 1) continuing evaluation of solar rock-storage heating system which involves an under bench rock-storage combined with an attic collector; 2) further evaluation of an under bench water storage/heat exchanger with a polycollector; 3) observation of foliage and flowering plant growth and their reactions to a reduced light environment generated by a solar attic collector in a greenhouse setting; 4) constructed and began preliminary evaluation of sawtooth design greenhouse; 5) continued research on energy efficient greenhouse design and of ridge and gutter naturally cooled greenhouses.
SUPPORTED BY: Florida State Government.

1.0030
SOLAR GREENHOUSE HEATING AND COOLING
Baird CD, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida 32601,* (FLA-AG-01793)
OBJECTIVE: Develop and evaluate solar heating and cooling systems for greenhouses.
APPROACH: Modify existing greenhouses at Brandenton AREC to accommodate solar heating components. Emphasis will be placed on assembling a complete system as soon as possible in order to obtain data on the overall performance of the system, including the interactions between the solar collectors, thermal storage, and heat exchangers. Systems using water as the heat transfer and storage medium will be compared with systems utilizing air and rock storage.
PROGRESS: The high cost of greenhouse heating, even in southern states, and the uncertainty of future fuel supplies are causing greenhouse operators to seek alternate sources of energy. Solar energy, although still very expensive when compared to current fuel prices, is receiving considerable attention from both researchers and commercial operators. Two basic types of solar greenhouse heating systems are being tested in Florida; one using water as the working fluid and the storage medium, and the other using air as the transfer fluid and rock for storage. The water system uses external low-cost plastic collectors and an integrated heat exchanger/storage tank placed under the plant support benches. This heat exchanger/storage tank is essentially a vinyl-lined sheet-metal tank covered with a shell that channels air over the warm tank for night time heating. The air system utilizes a rock bed under the plant support benches and a suspended screen in the attic of the greenhouse for the solar collector. Polypropylene shade cloth (25%-50%) is used as the heat absorbing screen and is sealed off from the plant growth area by clear poly. This system has the advantage over the water system in that the greenhouse structure provides the major components of the solar collectors, but has the disadvantage of being applicable only to those crops that can tolerate significant light reduction (such as ornamental foliage plants).
SUPPORTED BY: Florida State Government.

1.0031
DRYING SEAFOOD PRODUCTS WITH SOLAR ENERGY
Baird CD, Chau KV, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601,* (FLA-AG-01990)
OBJECTIVE: Develop and study low-cost solar driers that can be used to dry seafood and mullet roe in Florida and southern states; optimize solar seafood drying process and investigate the parameters that will affect product quality such as collector material and configuration, radiation rate, air flow rate, drying temperature and humidity, intermittent or continuous drying, etc. Investigate the need for heat storage for use at night and during cloudy periods based on product quality and economic feasibility; investigate the efficiency and potential energy saving of different solar fish drying systems.
APPROACH: In addition to mullet roe, two types of fish products will be dried, one is minced fish flesh made from sheepshead, primarily white flesh, the other is fish fillets made from mullet consisting of white and dark flesh. Two types of solar dryers will be tested. One is a cabinet-type using direct heating of the product with convection air flow for moisture removal. The other is a tray-type with forced convection drying using solar heated air. The later dryer will be equipped with collectors that are efficient and economically feasible. Different processing parameters will be investigated in order to obtain optimum conditions for processing the dry seafood products with a high quality and processing costs that are not excessive.
SUPPORTED BY: Florida State Government.

1.0032
GRAIN DRYING WITH SOLAR ENERGY IN THE HUMID SOUTH
Baird CD, Chau KV, Bagnall LO, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601,* (FLA-AG-01852)
OBJECTIVE: Develop and evaluate grain solar drying systems.
APPROACH: Construct plastic solar collectors and conduct corn and soybean drying tests using two 100-bushel metal bins. Various air flow rates will be used. The tests wil include drying experiments during the daytime hours only, drying experiments with the blowers run all day and all night, and experiments with the blowers on a humidistate setting at night. Temperatures throughout the collector, temperature profiles in the grain bins as well as the relative humidity, ambint temperature, insolation will be monitored and recorded by a data acquisition system.
PROGRESS: The purpose of this research project is to find the most appropriate methods of applying solar energy to grain drying in the Southeast. Research thus far has concentrated on low-cost plastic solar collectors connected to conventional grain storage bins with depths up to 1.7m. It is technically feasible to dry grain with solar energy under conditions of high humidity and high temperatures in the Southeast, however, drying has to be done within a few days to a week or less. Solar grain drying is still not economical (considering all costs) when compared to the present cost of fuel and based on a 30 day drying season. A recent modification of the suspended plastic screen collector used for grain drying, resulted in a significant reduction in cost. The material costs, including the inflation blower, is less than $4/m (2) while the collection efficiency ranges from 30-45% for a 15-25 degrees C temperature rise. A collector with two suspended plastic screens is significantly more efficient (20-25% more efficient) than one with a single screen. Solar grain drying tests conducted over a three year period indicate that about 4 m (2) of solar collector are required to reduce the moisture content of 1 ton of shelled corn 1% dry basis per day. A system similar to the one being tested at the University of Florida has been designed for solar corn drying in Central America and shows promise of being economically feasible.
SUPPORTED BY: Florida State Government.

1.0033
GRAIN DRYING WITH SOLAR ENERGY IN THE HUMID SOUTH
Baird CD, Hartsock JG, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601,* (3090-20594-025-A(1))
OBJECTIVE: Determine the technical and economic feasibility of using solar energy for grain drying in the warm, humid, southern part of the United States.
APPROACH: Conduct experimental solar grain drying tests to determine conditions necessary to prevent spoilage under adverse southeastern weather conditions. Make an overall evaluation of the feasibility of solar grain drying in the Southeast and propose guidelines, especially in view of the high susceptibility of the grain to aflatoxin contamination, as well as other types of spoilage. Further improve the low-cost suspended plastic collector and develop extension-type construction plans for this revised design.
PROGRESS: Evaluations of solar-assisted drying were made under the high temperature and high humidity conditions of the Southeast, which require rapid drying to avoid spoilage and possible aflatoxin contamination. An inexpensive plastic collector with a suspended plastic screen as an absorber above an insulated black backplate provided sufficient temperature rise. Both corn and soybeans were dried successfully without aflatoxin by use of high airflows of 10cfm/bu or higher and relatively shallow depths of two feet or less. A fuel system back-up, in case of bad weather, is essential. Attempts to use existing roofs as bare-plate collectors by enclosing the rafters and circulating air beneath the roof surface were deemed not to

give adequate collection efficiency at the relatively high temperature rise needed.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0034
IMPROVED UTILIZATION OF SOLAR ENERGY ON TROPICAL FARMS
Baird CD, Ingley HA, Farber EA, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601,* (7002-20518-001-A(1))
OBJECTIVE: To upgrade technical base for use of solar energy in rural areas of the tropics. To develop an effective energy conversion package capable of meeting the basic needs for home food processing and preparation.
APPROACH: Develop and extend data base on solar energy potentials in selected tropical areas. Examine energy uses on farms and in rural villages to identify critical uses for food processing and preparation. Develop simple system to satisfy identified needs. Test system in the laboratory and on site to verify effectiveness.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0035
DESICCANT DRYING AND SOLAR ENERGY REGENERATION FOR FRUIT AND VEGETABLE DRYING
Bowman EK, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601,* (FLA-AG-01909)
OBJECTIVE: Develop elemental cost data covering: desiccant materials; equipment design approaches and features. Develop appropriate rates and relationships as basis for input requirements. Carry out analytical work and develop cost relationships for selected component and system alternatives. Express results in terms appropriate for industry use.
APPROACH: Established engineering/economic techniques will be used in all steps of cost investigation. Both ownership and operating requirements will be considered in cost projections. Alternative components and systems considered in evaluation will be selected in the light of experimental performance and potential.
PROGRESS: Cost figures including ownership and operating costs, subject to further refinement, were developed for the conventional heated-air method of surface drying fresh citrus. Based upon use of the same equipment line for oranges and grapefruit, and 1300 hours of scheduled operation per season, the costs, per 1000 field boxes of fruit packed out, are: 41 dollars for a packinghouse rated for about 500 field boxes per hour and 37 dollars for houses rated for about 1000 and 1500 field boxes per hour. The cost portion for steam ranged from 40 to 47%.
SUPPORTED BY: Florida State Government.

1.0036
SOLAR ENERGY UTILIZATION FOR TROPICAL FARMS
Farber EA, Ingley HA, Baird CD, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601,* (FLA-AG-01967)
OBJECTIVE: Upgrade technical base in rural and farming areas of the world using alternative energy; selection of energy conversion system capable of meeting basic needs of study group.
APPROACH: Develop data base on alternative energies found in studied region. Examine needs of rural forms and develop simple system capable of converting solar energy to meet the assessed need. Build and test the developed system. Install system on site.
SUPPORTED BY: Florida State Government.

1.0037
DRYING SEAFOOD PRODUCTS WITH SOLAR ENERGY
Deng JC, Dept. of Food Science & Human Nutrition, University of Florida, *Gainesville, Florida, 32601,* (FLA-FS-01990)
OBJECTIVE: Develop and study low-cost solar driers that can be used to dry seafood and mullet roe in Florida and southern states. Optimize solar seafood drying process and investigate the parameters that will affect product quality such as collector material and configuration, radiation rate, air flow rate, drying temperature and humidity, intermittent or continuous drying, etc. Investigate the need for heat storage for use at night and during cloudy periods based on product quality and economic feasibility. Investigate the efficiency and potential energy saving of different solar fish drying systems.
APPROACH: In addition to mullet roe, two types of fish products will be dried, one is minced fish flesh made from sheepshead, primarily white flesh, the other is fish fillets made from mullet consisting of white and dark flesh. Two types of solar dryers will be tested. One is a cabinet-type using direct heating at the product with convection air flow for moisture removal. The other is a tray-type with forced convection drying using solar heated air. The later dryer will be equipped with collectors that are efficient and economically feasible. Different processing parameters will be investigated in order to obtain optimum conditions for processing the dry seafood products with a high quality and at processing costs that are not excessive.
PROGRESS: Mullet roe was dried in 3 ft (3) cabinets using direct insolation where energy is obtained by product absorption of solar energy. Little difference in drying rate or product temperature was observed for units having side-to-side or bottom-to-top airflow patterns (15 ft (3)/min airflow). Falling rate drying kinetics were observed. Varying airflow rates altered drying rates. Lowest airflow (17.3 ft (3)/min) gave increased product temperatures and higher drying rates than units with higher airflows (43.4 and 50.8 ft (3)/min). This reduction of product temperature with increased airflow is unlike forced air drying where increasing airflows would give increased product temperatures with rapid drying rates. An experimental flat-plate solar collector and smokehouse chamber were designed and constructed to determine the feasibility of substituting solar energy for fossil fuel in the fish hot smoking process. Modifications to the simple flat plate collector were made to increase the air temperatures without decreasing collector efficiency.
SUPPORTED BY: Florida State Government.

1.0038
DESICCANT DRYING AND SOLAR ENERGY REGENERATION FOR FRUIT AND VEGETABLE DRYING
Miller WM, Agricultural Research & Education Center, University of Florida, *Lake Alfred, Florida, 33850,* (FLA-CS-01909)
OBJECTIVE: Determine and collect the required design information for fruit drying based on desiccant water removal and solar regeneration of the desiccant. Design, construct and evaluate a pilot plant fruit drying system based on desiccant dehumidification of ambient air. Design, construct and evaluate a dessiccant solar regeneration system compatible with fruit dryer requirements. Design and construct a demonstration system integrating both desiccant dehumidification and solar regeneration of the desiccant.
APPROACH: Determine feasibility of desiccant drying/solar energy regeneration as an energy alternative in fruit and vegetable surface moisture drying. Develop and design pilot plant equipment for evaluating both desiccant drying and solar desiccant drying regeneration. Fabricate a pilot system to demonstrate proof of concept for utilization in citrus and other fruit and vegetable operations.
PROGRESS: Dehumidification dryer tests were conducted to analyze control strategies for desiccant utilization. After 1 hour, humidity ration difference (HRD) levels decreased to 0.0060 kg/kg after an initial level of 0.0092 kg/kg. Complete dispensing of the spent desiccant and recharging with fresh material increased the HRD level to 0.0083. However, resultant moisture content was only 10.7/compared to 17-20/in batch type tests. Extended dehumidification tests were undertaken to establish the HRD decay phenomena for a static bed of desiccant. A pilot-scale desiccant regeneration system utilizing direct insulation was completed. Storage hoppers and augering devices for both spent and regenerated solid desiccants were installed. Electrical wiring and installation of control components were also completed. A GASP IV computer simulation program was completed which predicted desorption of desiccants by direct solar exposure. Main discrepancy was the effect of air flow rate on moisture desorption. At higher air flow rates, 0.02 m (3)/s, predicted and experimental results were within 2.5% moisture content, dry weight basis.
SUPPORTED BY: Florida State Government.

1.0039
SURFACE DRYING CITRUS WITH SOLAR REGENERATED DESICCANTS
Miller WM, Berry RE, Agricultural Research & Education Center, University of Florida, *Lake Alfred, Florida, 33850,* (7096-20510-014-A(2))
OBJECTIVE: Determine design information for fruit drying based on desiccant and solar regeneration. Design, construct and evaluate pilot system. Determine best desiccants based on regeneration, water capacities, adsorption rates and cost. Develop plans for large-scale solar regenerative dryer.
APPROACH: Survey desiccant drying techniques and direct solar regeneration systems. Design regenerative collector and fabricate. Study comparative features, e.g., single vs. double glass, natural vs. forced air, rate of desiccant flow, equilibrium moisture content at different temperatures and desorption rates as a function of these parameters. Optimum operating conditions to establish most feasible desiccants will be determined. Recommended designs and criteria will be developed for a prototype desiccant regenerative fruit dryer.
PROGRESS: Laboratory tests were conducted on four commercially available desiccants: activated alumina, anhydrous calcium sulfate, molecular sieve and silica gel. Moisture adsorption desorption characteristics indicate activated alumina and silica gel had best potential for solar regeneration. These desiccants were regenerated by direct solar exposure during both winter and summer conditions. Flat-plate collectors of 2.3 m 2 area, with a single glass cover and tray inserts, were used. Useful energy was calculated using mass of water vaporized and latent heat of vaporization. With silica gel at 8.1 to 12.2 kg/m 2 solar energy utilization was 28 to 38%.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0040
DEHYDRATION OF SOUTHEASTERN FRUITS AND VEGETABLES BY SOLAR ENERGY
Berry RE, Bryan WL, Wagner CJ, Agricultural Research, U.S. Dept. of Agriculture, *Winter Haven, Florida, 33880,* (7608-20510-013)
OBJECTIVE: Develop practical dehydration process for food and agricultural products using solar energy augmented by fossil energy sources when necessary, to develop new dehydrated fruit and vegetable products.
APPROACH: Survey previous work, design and construct batch-type solar dehydrator, test dehydrator on traditionally dried as well as unique tropical and subtropical fruits and vegetables; assess and select food products most compatible with this type dehydration. Develop combination dryers with flexibility of diverting between solar and conventional energy sources. Design for optimum commercial application. Test flavor quality. storage stability of fruit and vegetable products.
PROGRESS: A low-cost, small-scale solar dryer was developed for use on small farms or communities. It is easily constructed with inexpensive materials and uses a unique parabolic trough type reflector to increase radiation on the product and shorten drying time. Drying rate data have been obtained on this dryer, and satisfactory sample products prepared from grapes, mangos, mushrooms, peaches, and plantains. Stored solar and hot-air dried green peppers indicated no significant differences between solar dried and conventional products in retention of vitamin C, flavor and color. Concentrations of SO(2) and hypochlorite necessary for preserving color and reducing bacteria have been established for dried mushrooms and some vegetable products.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0041
DRYING FRUITS AND VEGETABLES WITH SOLAR ENERGY
Perry JS, Agricultural Experiment Station, University of Georgia, *Athens, Georgia, 30602,* (GEO00694)
OBJECTIVE: Establish design data for drying fruits and vegetables including the effect of direct exposure to solar radiation. Design and testing of a batch-type drier utilizing solar energy either directly or indirectly, supplemented with an auxiliary energy soruce for emergency or off-peak use.
APPROACH: Enclosed drying trays are to be constructed with glazing covers. Air under controlled conditions of temperature, humidity, and air-flow rates will be utilized while treatments will include direct exposure to solar radiation during drying with drying rates and final product quality the measured variables. Based on the data obtained a batch-type drier with an appropriate auxiliary energy source will be constructed and tested.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0042
USE OF SOLAR HEATED AIR IN AGRICULTURE
McLendon BD, Allison JM, Dept. of Agricultural Engineering, University of Georgia, *Athens, Georgia, 30602,* (GEO00529)
OBJECTIVE: Evaluate the characteristics of selected types of air heating solar collectors operating in conjunction with agricultural product drying systems and environmentally modified animal housing and develop guidelines for operation of solar assisted drying systems in the Southeast.
APPROACH: Commercially available and experimental collectors will be tested over various volumetric flow rates and conditions. A prototype drying system will be used to evaluate product drying characteristics. A linear system model will be developed for optimizing system components. Solar energy with rock storage of heat supplemented as necessary with electric heat will be used for brooding baby chicks confined for 4-weeks to a 1/3-section of a broiler house. Attempts will be made to adapt portions of the system for environmental modifications in swine and calf housing.
PROGRESS: During the Fall of 1979 corn was dried using solar, with and without storage, biomass and electrical. Drying schemes investigated included (a) conventional drying; (b) intermittent: (1) drying from 10 p.m. to 10 a.m. then OFF for 12 hours, (2) drying for 30 minutes then OFF for 30 minutes, (3) drying for 15 minutes then OFF for 45 minutes, (4) drying when solar energy, direct and stored, would keep RH below 60%, (5) drying with biomass heated air from 8 a.m. to 1 a.m., and (b) drying with direct solar heat air as long as RH is held below 60% otherwise use electrical heat to keep RH below 60%. Preliminary results show that when the systems are cycled energy can be conserved without damage to the grain. Conventional drying required 8.5 kWh/m (3) M.P. with a drying rate of 4 M.P./day as compared to cycling at a rate of 30 minutes on 30 minutes off which required 6.8 kWh/m (3) M.P. with a drying rate of (3) M.P./day. When the drying cycle was interrupted from 10 a.m. to 10 p.m. 13 kWh/m (3) M.P. was required at a drying rate of 2 M.P./day. The system which was cycled off for 45 minutes of each hour required only 4 kWh/m (3) M.P. and had a drying rate of 2 M.P./day. There was no mold growth.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0043
USE OF SOLAR HEATED WATER IN AGRICULTURE
McLendon BD, Allison JM, Dept. of Agricultural Engineering, University of Georgia, *Athens, Georgia, 30602,* (GEO00599)
OBJECTIVE: Optimize the relationship between solar collector size, efficiency, energy storage tank size, capacity of the supplemental heating system and rate of water use for selected systems. Evaluate several methods of using solar assisted water heating systems for underfloor heating of a concrete slab floor in animal housing and greenhouses.
APPROACH: A mathematical analysis of the interrelationships between solar collector size, supplemental energy, system efficiency, storage tank size, and water use rate will be made and the analysis results will be verified experimentally. A mathematical analysis of a floor underheat system will be made and two test sections (a 4' x 4' and a 4' x 8') will be made to evaluate the design equations developed. Using the design procedure developed, a concrete slab underheat system will be incorporated into broiler housing and greenhouses.
PROGRESS: A simulation model has been developed to facilitate sizing of major system components (e.g., solar collectors, storage tank, heat exchangers) in an alternate energy system. As developed, the model assumes use of a low cost collector constructed with 1.91 cm PVC pipes embedded in 7.02 cm of asphalt paving material. The energy management strategy involves the use of "off-peak" electrical energy as a supplemental energy source. The simulated load for the energy model is a totally enclosed fan ventilated broiler house. A verification of the model is currently being completed. The low cost water heating solar collector and a 3785 liter energy storage tank were used to supply stored solar energy for solar assisted grain drying.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0044
OPTIMIZE EFFICIENCY OF ENERGY UTILIZATION IN AGRICULTURAL HOUSING SYSTEMS
Manbeck HB, McLendon BD, Miller BR, Dept. of Agricultural Engineering, University of Georgia, *Athens, Georgia, 30602,* (GEO00701)
OBJECTIVE: Determine energy consumption of existing agricultural housing systems. Increase efficiency of energy utilization in agricultural housing systems through development and evaluation of technological and management alternatives. Evaluate efficiencies of agricultural housing systems.
APPROACH: Energy consumption in both naturally ventilated and environmentally modified production broiler houses will be monitored. The data base will be used to validate simulation models for energy consumption. The validated model will be used to select design and management parameters for more energy efficient housing systems in North East Georgia. Economic analyses will be performed for a solar water heating system in commercial dairies. The results will be extended to permit evaluations of statewide usage of solar water heating.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0045
ECONOMIC ANALYSIS OF ENERGY CONSERVATION ON GEORGIA DAIRIES
Miller BR, Dept. of Agricultural Economics, University of Georgia, *Athens, Georgia, 30601,* (FG44-80R410160)
OBJECTIVE: This project will demonstrate the commercial application of existing technology.
APPROACH: Solar reflectors will be built with on-shelf materials available to local people. Measuring devices will be attached that will allow detailed and accurate economic analysis of system performance under commercial real world conditions. This project will lower the cost of milk production and should ultimately benefit both farmers and consumers. Beyond that, the existence of operating solar systems in the rural area will stimulate interest and application in alternative uses. This project will be constructed on a commercial dairy near Winder, Georgia. It will use a waste heat scavenger sold and installed by an Athens, Georgia, firm and solar equipment that is manufactured, sold, and installed by a Gainesville, Georgia, firm. Graduate students at the University of Georgia will monitor and analyze data generated by the project. There are approximately 930 dairymen in Georgia who will benefit immediately from this project. An equivalent number in each of the surrounding states will likewise benefit through the publication channels of the Georgia Agricultural Experiment Station.
SUPPORTED BY: U.S. Dept. of Energy.

1.0046
DEVELOP IMPROVED TECHNOLOGY FOR PRODUCTION OF LOW-COST QUALITY FEED PRODUCTS FROM SOUTHERN FORAGES
Spencer RR, Albrecht WJ, Burdick D, R.B. Russell Agricultural Research Center, U.S. Dept. of Agriculture, *Athens, Georgia, 30604,* (7902-20521-001)
OBJECTIVE: Develop practical methods of processing Southern forages to conserve energy and increase nutritive value and feed efficiency.
APPROACH: Investigate combination of field wilting and solar dehydration and chemical/physical treatment of Southern forages to reduce cost and improve quality (nutritive value) of the harvested crop. Forages to be investigated will include Coastal bermudagrass and arrowleaf clover. Use an inexpensive solar dehydrator to determine drying rates of the different forages. Obtain data on quality (chemical composition and digestibility) of the forages as related to treatments. Data obtained will provide the basis for maximizing processing Southern forages in least cost computerized feed formulations.
PROGRESS: The digestibility of low quality Coastal bermudagrass (8.5% protein) can be increased by the combination of alkali treatment and the heat produced in the pelleting of the ground forage. Sodium hydroxide levels of 3 and 7% increased the IVDMD of the pelleted products from 37 to 47 and 55%, respectively. Pre-harvest treatment of Coastal bermudagrass was 1, 2, 4 or 8% aqueous formic or acetic acid reduced the standing plants' moisture content by less than 5%. These tests were conducted under extreme dry conditions which may have adversely effected these results. Coastal bermudagrass hay was wilted in the field to approximately 30% moisture and drying completed with air heated by a solar collector. Evaporation efficiency (water removed/heat delivered) was about 35% for loose hay and 23% for baled hay. Overall efficiency (collector plus evaporation efficiency) was 25% for loose hay and 17% for drying bales. However, baled hay produced 1.2 lbs dry hay/day/cubic foot of drier volume compared to only 0.55 lbs from the loose hay. Preliminary trials to determine field dry matter and nutrient losses during production of hay from Coastal bermudagrass have shown dry matter losses of 32% and protein losses of 16%. These losses were determined under poor haying conditions (i.e., rain, and army worm infestation) which adversely effect the results.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0047
ASSESSMENT OF TECHNOLOGY IN THE FOOD AND FIBER SYSTEM
Miller ME, U.S. Dept. of Agriculture, National Economic Analysis Div., University of Georgia, *Athens, Georgia, 30601,* (NEA-12-107-13-01)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and interregional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Solar energy applications research continued with data gathering and consulting with SEA/AR and SAES engineers. The major applications were tobacco irrigation, peanut drying, and greenhouse heating. Solar powered irrigation was also studied but not as intensely as the other areas. The feasibility of feeding crop residues to beef cattle was studied. The study inventoried residues on a county-by-county basis, estimated the economic values of residues, and identified the economic effects of reducing grains and increasing forage and residues. Data was gathered to

compare trends in technology and productivity in processing and distribution. Uses of agricultural products in manufactured goods were identified.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

1.0048
NURSERY AND GREENHOUSE MECHANIZATION
Verma BP, Dept. of Agricultural Engineering, University of Georgia, *Experiment, Georgia, 30212,* (GEO01201)
OBJECTIVE: Research and develop facilities and equipment for an efficient energy and labor utilization in the production of nursery and greenhouse crops.
APPROACH: Growing areas with controlled traffic pattern will be used in conjunction with a mobile platform. Equipment and facilities will be developed for fertilizing, materials handling, weather protection, etc. Recessed growing areas in the ground with subsurface irrigation and solar heating will be tested to determine if a greenhouse could be replaced with such arrangements. A systems analysis of the production systems is also planned.
PROGRESS: Time and motion data were analyzed for performing various tasks in nursery operations. Additionally, a new system of materials handling was tested. Based on these data, computer simulation models using GASP IV Simulation Language, are being developed to evaluate several alternative system concepts. Some of these models have been developed and they will be compared with other systems for evaluating system efficiency improvement. A concept of container design was tested to reduce high root zone temperatures in container soil. It was proposed that if the plastic containers had a way to cool themselves in a manner similar to clay containers, the root zone temperatures may be reduced. Containers were made out of plastic screen materials of various mesh. Root zone temperature in the containers made from plastic screen was 19 degrees C cooler.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0049
LABORATORY AND PILOT-SCALE STUDIES OF FLUIDIZED-BED DRYING FOR CONTROL OF STORED-PRODUCT INSECTS
Vardell HH, Tilton EW, Stored Products Insects Research and Development Lab, U.S. Dept. of Agriculture, Agricultural Research, *Savannah, Georgia, 31405,* (7705-20620-044)
OBJECTIVE: Adapt fluidized-bed drying techniques that may include solar-heated air for use as a nonpesticidal means of controlling stored-product insects in grain.
APPROACH: Initially the effects of various drying temperatures and times necessary for the control of insects infesting various grains subjected to fluidized-bed drying will be investigated. Cooperative studies will be conducted with pilot-plant operations to determine the most effective use of fluidized-bed drying techniques for insect control.
PROGRESS: A laboratory-scale fluidized bed was designed and constructed for use in this project. Control of all stages of the lesser grain borer and the rice weevil infesting wheat was attained by use of a heated fluidized bed. To achieve this control required treatment temperature of 67 degrees or 60 degrees C. for the lesser grain borer or the rice weevil, respectively. In this test the infested grain was heated to the treatment temperature and then removed from the fluidized bed and allowed to cool to ambient temperature.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0050
A SOLAR ENERGY - PETROLEUM CONSERVATION SYSTEM FOR CURING TOBACCO
Cundiff JS, Butler JL, Dept. of Agricultural Engineering, University of Georgia, *Tifton, Georgia, 31794,* (7098-20190-010-A(1))
OBJECTIVE: Determine the system parameters for a tobacco curing system which utilizes solar energy, supplemented by a heat pump to totally eliminate LP gas and fuel oil for tobacco curing.
APPROACH: A scale prototype consisting of three one-fifth scale curing chambers, an existing flat plate solar collector and rock storage and an electric heat pump, to be used in off-peak hours, will be used to cure tobacco in the bulk. Heat from the solar collector will be stored in the rock bed to be used in the curing phase. For the high temperature 170 F, steam drying phase, an electric heat pump will be used to elevate the temperature. Heat will be recovered from the exhaust air during the final phase of curing. A microcomputer will be used to optomize the control functions during the testing of the prototype.
PROGRESS: Three one-fifth scale bulk curing units were connected to an existing solar energy collector/storage system which used a rock storage system. A small water heater was installed to provide heat for the high temperature curing phase. Six cures were made in two of the units and five cures were made in the other. A grower's barn, manufactured by the same company as the scale units and with identical wall and roof construction, was used as the control barn. The first four cures were made in 144 hours per cure. The fifth and sixth cures were upper stalk fully field ripened tobacco. These were cured on a 4 1/2-day curing schedule or 112 hours per cure. The cured tobacco had excellent characteristics and sold for the top market price. The supplemental heat added to the solar barns was 5 MJ/kg cured solids. This compares with a seasonal average of 20 MJ/kg cured solids in the control barn which had the same insulation in the ceiling, walls, doors, and underneath the concrete slab. Thus 75% of the heat energy required was supplied by the solar system.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0051
DEVELOPMENT OF ENERGY EFFICIENT SYSTEMS FOR PEANUT HARVESTING AND DRYING IN THE SOUTHEAST
Troeger JM, Williams EJ, U.S. Dept. of Agriculture, Agricultural Research, *Tifton, Georgia, 31794,* (7702-20190-020)
OBJECTIVE: Develop procedures and equipment which will reduce the need for nonrenewable fossil fuel in the harvesting and drying of peanuts while maintaining peanut quality.
APPROACH: Various methods of collecting, storing, and using solar energy for peanut drying will be evaluated. Procedures and equipment will be developed and evaluated for more efficient use of energy during drying, including intermittent airflow and partial recycling of the drying air. Energy conservation methods will be evaluated in combination with solar drying. Peanut quality will be evaluated for each test. Computer simulation model of solar drying will be used in conjunction with experimental data to develop design recommendations for solar drying facilities. An economic analysis will be made of the solar collection-storage system, considering year round use of other agricultural purposes outside the drying season.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0052
AIR-DRYING, FREEZE-DRYING, AND OSMOVAC-DEHYDRATION OF FOODS WITH SOLAR ENERGY
Moy JH, Dept. of Food Science & Technology, University of Hawaii, *Honolulu, Hawaii, 96822,* (HAW00575-S)
OBJECTIVE: Develop technology of air drying of foods with solar energy emphasizing dryer design, drying efficiency, sanitation, product quality and engineering economics. Explore, test and develop technical feasibility of freeze drying and osmovac-dehydration of selected foods with solar energy. Determine the amount of conventional energy conserved resulting from solar energy utilization.
APPROACH: Design and construct prototype dryers to utilize direct solar radiation to dry root crops, tropical fruits and selected vegetables, measuring incident radiation, air movement, heat and mass transfer, thermal properties and qualities of samples, and engineering economics. Design and construct prototype systems for vacuum and nonvacuum freeze drying of selected foods with direct absorption of solar energy; also system for osmovac-dehydration of fruit pieces, using solar energy for syrup concentration and increased osmotic rate at higher temperature. Measure and compare energy consumption and conservation from above systems by substituting solar energy for conventional energy.
PROGRESS: Results of drying 6 mm thick papaya slices at a loading density of 5 kg/m (2) showed that combined mode solar dryer was more efficient than either direct or indirect solar dryer. However, if loading density was too high, such as 10 kg/m (2) for drying taro slices of 6 mm thick, airflow through samples became impeded; the combined mode dryer was less efficient than the direct solar dryer equipped with reflectors. Quality of solar dried taro slices were comparable to those of air dried or freeze dried samples after being stored in polyethylene bags at 38 degrees C for 18 months. Results showed that drying rates of 6 mm thick papaya slices in solar osmovac process were higher than those in non-solar osmovac runs (4 to 6 hrs in 60 degrees Brix syrup, than vacuum dried). Product quality was acceptable except sucrose uptake was higher in samples from solar runs. In separate experiments, papaya slices that were first dried in a heavy syrup (60 degrees Brix) with solar energy for 4 to 6 hrs, then dried in the combined mode solar dryer, were found to have very good quality and could mean bypassing the vacuum drying step in the osmovac process.
SUPPORTED BY: Hawaii State Government.

1.0053
AIR-DRYING AND OSMOVAC-DEHYDRATION OF FOODS WITH SOLAR ENERGY
Moy JH, Berry RE, Dept. of Food Science & Technology, University of Hawaii, *Honolulu, Hawaii, 96822,* (7092-20510-008-A(1))
OBJECTIVE: Using solar air drying and osmovac dehydration determine efficiency of heat and mass transfer, physics and chemistry of effects on tropical food products, sanitation requirements, effectiveness of auxilliary air moving devices, optimum drying design and rate measurements and engineering economics.
APPROACH: Compare direct absorption effects on tropical roots and fruits with effects of solar dryer using forced air, augmented with conventional energy. Determine osmotic dehydration effects when syrup is heated directly by solar radiation. Concentrate osmotic syrup using direct solar radiation and develop system for contacting concentrated syrup with fruits and juices to concentrate solids. Determine drying rates vs. loading density, depth, uniformity, surface/volume, temperatures and moisture contents. Develop criteria to design home or commercial dryers or concentrators.
PROGRESS: No progress has been made on this project since the report one year ago. Actual work has terminated on this project, but the project manager has not completed the final report. Final quarterly payment on this project is being withheld pending receipt of the final report, which the project manager indicates is currently in process and will be forthcoming shortly.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0054
SOIL AND PLANT WATER RELATIONS AND MICROCLIMATE INTERACTIONS AS THEY AFFECT PLANT GROWTH
Cary JW, Snake River Conservation Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Twin Falls, Idaho, 83341,* (5818-20740-003)
OBJECTIVE: Pinpoint specific short term soil water and microclimate conditions that substantially alter plant production and quality, and seek practical management techiques to advantage of the new knowledge.
APPROACH: Plant parameters such as water relations, nutrition levels, CO(2) assimilation and yields will be studied on field plots subjected to various methods of tillage and irrigation water management. Growth chambers will be used in the winter to provide preliminary information for optimum experimental design and procedures. Root systems will be studied in both the field and laboratory with respect to soil structure, temperature nutrition, and water relations. Em-

phasis will be on intensive short term measurements of plant physiological response in the field to soil and microclimate conditions that can be quantitatively defined and monitored.
PROGRESS: A study of coupled heat and water vapor flow in soil resulted in the derivation of a fundamental equation that enables predicting temperature induced water vapor flow from the soil's bulk density, water and quartz contents, temperature distribution, and its saturated thermal conductivity. This equation will be useful in the analytical solution of soil drying and water storage problems as well as engineering designs associated with the safe burial of radioactive wastes and the storage of solar energy in soil for later retrieval during cold periods. The development of appropriate theory and experimental techniques were begun on three studies involving: creation of design criteria to see if it is feasible to develop a microprocessor to schedule irrigations from soil water measurements; the characterization of leaf properties that limit CO(2) fixation of plants under field conditions; and the treatment and propagation of pinto bean seeds to be screened for shifts toward cold resistance following chemically induced mutations.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0055
NEW AND IMPROVED SYSTEMS, METHODS, AND TECHNIQUES FOR PROCESSING HARDWOODS
Rosen HN, North Central Forest Experiment Station, U.S. Dept. of Agriculture, *Carbondale, Illinois, 62901,* (NC-3201)
OBJECTIVE: Develop new and improved processes and conversion systems, reduce processing costs in the hardwood products industries, and extend the supply of high-value and high-quality hardwood timber.
APPROACH: We will develop new drying methods (high pressure) as well as improved old ones (solar drying) to rapidly dry lumber with minimal defect. Fundamental work in basic heat and mass transfer will support this work. New techniques will be applied to the machining of dimension material so that the best surface with the least waste can be obtained. The new technology developed in drying and machining will be applied to a model hardwood dimension plant. Characterization of raw material, adaptability of new technology, and an evaluation of process economy for finished parts will be determined.
PROGRESS: If we are to extend the supply of high-value species through the increased use of logging residues, we must improve our secondary processing systems. New methods must be developed in drying and machining to reduce costs, time, and energy consumption. A solar kiln heated with an external collector was able to predry 4/4 yellow-polar lumber from green (99 percent) to 15 percent moisture content up to six times faster than air drying throughout the year. The potential for energy recovery from the hot and humid vent air stream of a high-temperature dryer was evaluated over a wide range of operating conditions. Up to 22 percent of the energy consumed in drying could be saved by recovering energy from the high-temperature dryer. Basic orthogonal woodcutting studies have provided insight for the development of other cutting methods across the grain such as peripheral milling with rake angles up to 60 degrees and face milling dimension cuttings. Defect depth can be reduced from an excess of 1/16 inch to less than 1/32 inch as compared with conventional knife planing along the grain. A high-quality flake for particleboard instead of a planner shaving can be produced as a secondary product.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

1.0056
STUDY ON SOLAR GREENHOUSE TEST MARKET
Ketels P, Market Facts Inc., *Chicago, Illinois, 60606,* (BD 9 8376 0115)
OBJECTIVE: This study is part of an overall program designed to assess and identify passive solar energy technologies which have the potential for significant near-term impact on reducing residential consumption of conventional energy. A sub-tier of the overall program is to evaluate the awareness/acceptance level for passive solar products within the market place. The North East Solar Energy Center (NESEC) and Grossman's retail lumber outlets have jointly agreed to test-market a greenhouse/sunspace. The methodology and results of this program will be used to evaluate test markets for other passive solar products as they develop. It is intended to turn the methodology and approach over to the RSEC's for implementation in their respective regions as they see fit. The results of the study will also be used in the passive solar public relations/communications program, which is currently on-going, as a means of targeting efforts of the communications effort. The objectives are: (1) evaluate, through unsolicited voluntary participation of visitors, the open house and display of a solar greenhouse as a pilot passive solar product test market; and (2) provide a follow-up measure of intention, from those volunteers who give their permission, to install solar greenhouses along with the types of information required by the consumer. Unsolicited, voluntary on-site personal interviews will be conducted during the open house to measure initial reactions to the solar greenhouse display and voluntary follow-up interviews will be conducted to explore what open house visitors have done, or not done, about building the greenhouse.
SUPPORTED BY: U.S. Dept. of Energy.

1.0057
ASSESSMENT OF TECHNOLOGY IN THE FOOD AND FIBER SYSTEM
Miller ME, National Economic Division, U.S. Dept. of Agriculture, Economics & Statistics Service, *Peoria, Illinois, 61604,* (NEA-12-107-17-05)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Solar energy applications research continued with data gathering and consulting with SEA/AR and SAES engineers. The major applications were tobacco irrigation, peanut drying, and greenhouse heating. Solar powered irrigation was also studied but not as intensely as the other areas. The feasibility of feeding crop residues to beef cattle was studied. The study inventoried residues on a county-by-county basis, estimated the economic values of residues, and identified the economic effects of reducing grains and increasing forage and residues. Data was gathered to compare trends in technology and productivity in processing and distribution. Uses of agricultural products in manufactured goods were identified.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

1.0058
IMPROVED ANALYSIS AND DESIGN OF FARM BUILDINGS
Curtis JO, Scarborough JN, Carson JM, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-10-0372)
OBJECTIVE: Conceive and evaluate improved procedures of structural analysis and design. Develop and evaluate new or improved structural systems. Evaluate new building materials or new uses of existing materials for application in farm building construction.
APPROACH: A proposed improved analysis or design procedure will be applied in the design of a group of appropriate structural elements. Load tests will then be performed on these elements in full size or model form and the results of the load tests will be compared with those predicted by the analysis or design procedure. New materials and structural schemes will be evaluated by using them in production buildings and observing their performance and by subjecting them to a variety of simulated and accelerated tests.
PROGRESS: On the basis of analysis and review of information on lateral pressures from silage, assembled from many sources around the world, recommendations for lateral pressures from silage were proposed for incorporation into a new U.S. standard on silo design. Monitoring the performance of a solar collector, heat storage, and heat exchanger system, designed for retrofitting a swine nursery building, will indicate the system effectiveness in reducing the amount of heat that must be added to the building from petroleum based fuels. Construction is to be completed by mid-Winter 1979-80. Solar collectors, incorporated into the south facing halves of two existing swine buildings located on University research farms and used to add heat to the incoming ventilation air, are providing second winter performance data.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research office.

1.0059
SOLAR DRYING OF HIGH SPEED HAY ACCUMULATOR PACKAGES
Shove GC, Butler JL, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801,* (7002-20190-014A(1))
OBJECTIVE: Determine the design parameters for solar hay driers, evaluate the cost benefit ratio of these driers, and investigate the relationship of hay density to the drying process.
APPROACH: An air plenum capable of drying hay packages of various sizes and density will be used to gather drying process data. This will be used in an attempt to determine optimum bale density and air entry patterns. This will be used in conjunction with a portable covered plate solar energy collector to study collector parameters as they relate to the drying of large hay packages. The cost-benefit evaluation will be made on a solar hay drying facility which has the capacity to dry 36 large round bales, utilizing a 10,000square foot covered plate collector which is incorporated into the roof and the south wall of the building.
PROGRESS: Due to a delay in funding, the facility could not be completed in time to conduct studies during the normal hay curing season. During November, tests were run using large round bales, 1.8 m diameter by 1.5 m long. These bales which had an initial moisture content of 35-40 % were dried to a moisture content of 2-25%. Air flow rates of 7, 11, 42.5 and 56.6 m (3)/min were used. At the two lower air flow rates some spoilage occurred during these late fall tests indicating that supplemental heat would be desirable.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research.

1.0060
OPTIMIZATION OF FLAT PLATE SOLAR COLLECTORS FOR GRAIN DRYING
Shove GC, Hartsock JG, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801,* (3090-20594-033-G)
OBJECTIVE: Optimize the design of solar collectors for grain drying systems, particularly solar collectors incorporated in farm buildings.
APPROACH: Correlate the variations of the collected energy and design parameters of solar collectors incorporated into farm buildings. Determine optimal design of solar collectors for specified agricultural applications. Develop guidelines for selection and management of solar collectors applied to grain drying.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0061
THE EFFECTS OF RISK ON ILLINOIS FARMERS RELATED TO FARM ORGANIZATION, TAX REGULATION, AND FARM SIZE
Sonka ST, Scott JT, Dept. of Agricultural Economics, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-05-0305)
OBJECTIVE: Estimate crop variability by region in Illinois and its impact on modern farming operations. Estimate the effect of structural and financial organization and farm size on the ability to survive adverse occurrences. Estimate effects of risk, tax regulation, and farm organization on farm size.

Adapt or develop models useful in assessment of risk with variations in tax regulation, farm organization and farm size.
APPROACH: An attempt will be made to assess the risk and survival attributes of various farm production and financial decision strategies. Also the effect of regulations on farmer decision will be considered. Statistical analysis of farm production variability will provide a basis for understanding the risk position of Illinois Farmers. Simulation and optimization techniques can then be employed to compare various decision strategies farmers can employ.
PROGRESS: Previous work on this project indicating that solar grain drying could be feasible on farming operations but was not currently economic has been continued to define at what point alternative solar collectors, increasing fuel prices, or tax credits could make solar drying economic. Work has been completed which evaluated alternative measures for farmland property tax relief. These results indicate that several schemes could reduce tax payments and thereby increase the profitability of farmland ownership. The impact of these methods on the relative variability of cash flows was found to be significant only for landowners suffering severe liquidity problems. Research has been completed which evaluates alternative means of estimating changes in farm size over time. These results demonstrate considerable shortfalls of commonly used methods. During this period work has been initiated on three efforts. The first is an intensive examination of information needs of farm operators. A survey of Illinois farmers, lenders, and consultants has been conducted. Completed questionnaires are being evaluated. Economies of size on Illinois grain and swine farms are being evaluated. Based on actual farm records, this study will focus on the extent of size economies, the degree to which they have changed over time, and the impact of tax laws on these relationships. During the Summer of 1979, detailed weather and corn production data were collected for 100 locations in East-Central Illinois.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0062
SOLAR ENERGY FOR HEATING AND COOLING GREENHOUSES AND RURAL RESIDENCES
Dale AC, Butler JL, Dept. of Agricultural Engineering. Purdue University, *West Lafayette, Indiana. 47907,* (7091-20691-011-A(3))

OBJECTIVE: Develop a system for the collection, storage and utilization of solar energy for heating and cooling greenhouses, rural houses, or both.
APPROACH: A unique insulated solar energy collector will be constructed with reflector using air as an energy transfer medium. An insulated soil and groundwater field will be constructed and tested for storage of solar energy. Solar heated air will be circulated from the solar collector through the storage field 2 to 3 months prior to the heating season. Controls will be designed and the complete facility instrumented to evaluate both the collection system and earth storage system.
PROGRESS: The site fabricated solar air collector with concentrating reflectors combined with soil and groundwater thermal storage was operated with auxiliary heat input to facilitate measuring. (1) heat conduction coefficients between plastic tubes and saturated soil, (2) time required to heat saturated soil mass, (3) heat conduction through soil, and (4) heat loss characteristics of storage. Measurements indicate that system loses too much heat to surrounding soil and air. Although collector efficiency was measured at about 50%, the overall efficiency was only about 20%. Energy collected was at times balanced by energy losses for zero efficiency. To reduce energy losses the storage area will be covered with two layers of polyethylene. Since June 1,1978, the solar energy collector has been performing well. It is adding about 3/4 million Btu's/day to the soil and groundwater storage. The soil and groundwater temperatures have been raised to an average of about 75 degrees F as of June 15,1978. The collector is warming the return air as much as 80 degrees F. One measurement on a clear day in June showed the solar heated air to be entering the storage field at about 160 degrees F. The air flow was about 1800 cfm. Thus the system is now functioning as anticipated.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0063
SOLAR ENERGY COLLECTION, STORAGE, AND UTILIZATION FOR THE IMPROVEMENT OF LIVESTOCK AND CROP PRODUCTION
Dale AC, Jones HW, Hammer PA, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (IND046015)
OBJECTIVE: Develop solar energy collection systems, solar energy storages, and procedures for the utilization of solar energy to modify the environment for the improvement of both animal and crop production in cold and hot weather.
APPROACH: An insulated solar energy collector will be fabricated with reflectors to concentrate the solar energy. The reflectors will be placed at the top and bottom of the collector at such an angle so as to reflect additional solar energy into the collector to improve efficiency. Air will serve as the energy exchange medium between the collector and storage field. The solar heated air will be blown through pipe in an insulated energy storage field of soil and groundwater at a depth of eight feet for transfer of the heat to these materials. Starting in late August or early September, the collector will be placed in operation to build up the stored energy for use in heating animal shelters, shelters, greenhouses and farm houses in the winter. The stored heat will be recovered in a similar manner to which it was added to the soil and groundwater storage with the energy first being used to heat a greenhouse.
PROGRESS: A 2.43 m x 9.75 m solar heat energy collector and concrete block heat storage attached to the south wall of a farrowing house was operated (1) in the Winter of 1979 as a heating unit and (2) in the Summer of 1979 as a cooling unit. As a heating unit the system operated with an efficiency of 58%. It is estimated that the 23.70 m (2) solar collector saved 29.9 million kilojoules of energy for this farrowing house during 1978-1979. The average increase in temperature of the ventilation air passing through the 3/16" open vertical joints in the concrete block wall was 10.3 degrees C. In the summer, the system decreased the peak temperature of the ventilation air up to about 8.9 degrees C. The average reduction in temperature was 4.9 degress C. Work continued on the possibility of using a large soil and ground-water as a "long-time" storage for solar heat energy to heat a greenhouse. The results to date indicate that heat losses from the system are too great to maintain as high a level of temperature as needed. Thus little heat can be reclaimed from the storage.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0064
HEATING AND COOLING A SWINE FARROWING HOUSE WITH SOLAR ENERGY
Dale AC, Winter DW, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (7002-20400-014A(1))
OBJECTIVE: Determine the effectiveness of the Kansas State solar energy collector and storer in heating and cooling a swine farrowing shelter under Indiana conditions and observe effects of heating on control of infectious pathogens.
APPROACH: Adapt the Spillman design and construct the collector-storage unit as attachment to existing Purdue farrowing shelter. Obtain data on temperature, energy, and air flow to determine system performance. Monitor swine health and determine rate of gain of litters. Supply performance data to refine Spillman's model.
PROGRESS: A 2.43 m X 9.75 m solar heat energy collector and concrete block storage attached to the south wall of a farrowing house was operated (1) in the winter of 1979 as a heating unit and (2) in the Summer of 1979 as a cooling unit. As a heating unit the system operated with an efficiency of 58%. It is estimated that the 23.70 m (2) solar collector saved 29.9 million kilojoules of energy for this farrowing house during 1978-1979. The average increase in temperature of the ventilation air passing through the 3/16" open vertical joints in the concrete block wall was 10.3 degrees C. In the summer, the system decreased the peak temperature of the ventilation air up to about 8.9 degrees C. The average reduction in temperature was 4.9 degrees C.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0065
PROCESSING OF AGRICULTURAL PRODUCTS
Okos MR, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (IND046036)
OBJECTIVE: Develop energy efficient processing operations. Develop processing operations that minimize waste output. Develop economical processes for utilization and upgrading agricultural by-products and residues.
APPROACH: To accomplish the above objectives it will be necessary to monitor the energy use and wastes output of various food and grain processing operations. This information is important in identifying the significant variables causing high energy use and waste output. Modification in present processing techniques can save energy and lower the waste load. Alternative processing techniques such as concentration of dairy and vegetable products using membrane processing can lower energy costs. Careful investigation into the fundamental mass transfer, heat transfer and kinetic properties of foods will be investigated in order to design more efficient processes. Food processing by-products such as whey and underutilized foods such as corn and alfalfa will be enzymatically, chemically and mechanically treated to provide useful products for human consumption. Fermentation techniques will also be investigated to upgrade processing residues. Once the fundamental information is obtained, computer models can be developed to aid in the selection of energy efficient, economical, and waste free processes.
PROGRESS: Methods for conducting energy audits of plant unit operations were determined. Two actual plant audits are described, a dairy plant and pork processing operation. Estimated energy flow rates are compared with flows obtained from monitoring equipment which was installed in the plants. Utilization of energy by five processes in an integrated pork plant was evaluated. Energy flows through unit operations of each process have been measured using flow rate and temperature monitoring devices installed in the plant. Flow rates of steam, gas, water, refrigeration and electricity have been correlated with production. A detailed energy audit was performed in a dairy plant. The amount of energy necessary to produce fluid milk products, ice cream and cottage cheese is quantified for each unit operation. Refrigeration for storage is also studied. Overall correlations with plant utility bills are presented. Three thermal storage media; water, saturated soil, rock and phase change materials were tested to determine their feasibility as a media for thermal storage.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0066
SOLAR CONCENTRATION OF LIQUID FOODS
Okos MR, Berry RE, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (7005-20510-021A-(1))
OBJECTIVE: Determine feasibility of using solar energy for liquid food concentration using membrane processing, and other low energy unit operations such as immobilized enzymes and membrane demineralization systems.
APPROACH: Conduct experiments to determine effects of variable temperature on flux, rejection, fouling, microbial growth and membrane life using reverse osmosis and/or high pressure filtration for concentration of fruit juices, tomato juice and milk. Measure effects of residence time, microbial growth, sanitation on different liquid foods using solar energy as primary source, in a solar collector specifically designed for handling liquid food materials. Compare results with other potential low energy food processing unit operations, i.e., immobilized enzyme reactors and determine potential and compatibility of operation with solar availability.
PROGRESS: A solar heated membrane concentrator pilot plant has been constructed for concentrating whey and tomato juices. Effects of increased temperatures, achieved by solar heating, on

membrane concentration rates, are being studied. The pilot plant system has been operated in continuous, semi-continuous and batch modes. A bench-scale system for hydrolysis of lactose using immobilized enzyme columns has been constructed. Effects of increased temperature on hydrolysis of lactose by lactase in a plugged-flow type reactor are being studied. Increases in temperature are provided by a solar system.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0067
INFLATED PLASTIC STRUCTURES FOR SOLAR DRYING OF GRAIN
Buker RJ, Hartsock JG, (Performing Institution Not Reported), *Indiana,* (3090-20592-028-C)
OBJECTIVE: Develop and test a low-cost inflated plastic structure suitable for on-farm solar drying of grain.
APPROACH: Construct and test an inflated plastic structure 20 ft. x 85 ft. inflated by a centrifugal fan. Seal the earth floor with plastic sheet, place exhaust ducts on the floor, cover the ducts with 5000 bushels of grain and dry by downward circulation of solar-heated air. Record changes in grain moisture content, temperature, spoilage losses and costs.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0068
SOLAR ENERGY FOR GRAIN DRYING
Bern CJ, Hartsock JG, Dept. of Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (3090-15701-018A)
OBJECTIVE: Test methods of applying solar energy to low temperature drying of corn.
APPROACH: Investigate by a field test, the technical and economic feasibility of stir-drying corn in a combination mode in which wet corn is high-temperature dried to about 20 percent moisture and is then low-temperature solar dried to a safe storage moisture content. Continue investigation of the technical and economic feasibility of a combination desiccant/low-temperature drying system by means of a third field test. Continue investigation of the technical feasibility of stir-drying corn with surplus solar heat from the DOE demonstration solar heating system at Scattergood School by means of a second field test. Complete analyses and report results of the investigation of the technical and economic feasibility of an automatic control system for a solar-electric low-temperature drying system.
PROGRESS: Tests with a solar-assisted heat pump indicated that about 40% of the energy of the solar collector input was delivered as increased heat output from the heat pump. Successful drying of corn was accomplished with 0.18 Kwh/bu./% H(2)O removed with the heat pump vs. 0.22 with resistance heating alone. Successful low-temperature drying was again completed with a polyethylene-covered collector resulting in a saving of electric energy of 10-15%. An automatic control system for the fan and electric heater of a low-temperature drying system, based on a local PhD dissertation project, was constructed and installed. Actual drying tests will be part of the 1977-78 research program.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0069
A STRUCTURALLY INTEGRATED SOLAR COLLECTOR WALL FOR LIVESTOCK BUILDINGS
Bundy DS, Jones DL, Dept. of Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (IOW02330)
OBJECTIVE: Construct experimental integral wall collector. Gather data on operation. Evaluate design and performance of collector wall, both functionally and economically. Prepare evaluation, with recommendations for practical farm use, for technical publication and M.S. Thesis.
APPROACH: An integral wall solar collector will be constructed on ISU Ag 450 Farm. Data on collector and ventilation system performance will be collected over two winters and one summer. Preliminary results will be reported in a technical paper after the first winter, and final evaluation with design recommendations will be reported in an M.S. Thesis after the second winter of operation.
PROGRESS: In 1978, a 220-head swine nursery was constructed on an Iowa State University farm in Ames, Iowa. The nursery has a 2.44 m high by 9.14 m long, south, vertical, concrete-block solar collector wall for preheating winter ventilation air. Initial analysis of the integral solar collector wall indicates it is performing well, both functionally and economically. No proglems have come up that were not anticipated. More data will be analyzed before final conclusions are reached. Data compiled to date indicate that, although the collector wall may be significantly warming the incoming air up to 18 hours after last sunlight, the peak gain out of the baffle occurs only one to two hours later than peak temperature rise at the collector surface. Also, the peak output of the wall may be less than the building load, indicating the collector area will probably need to be larger if it is to supply both building load and heat storage. The collector shows an approximate fuel savings of 2 gal LP per square foot of collector per year.
SUPPORTED BY: Iowa State Government.

1.0070
ENERGY CONSERVATION IN DRYING, CONDITIONING, AND STORING CORN ON FARMS
Kline GL, Bern CJ, Anderson ME, Dept. of Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (IOW02132)
OBJECTIVE: Evaluate improved methods and equipment for drying, conditioning and storing corn on farms to conserve energy, maintain grain quality, and provide suitable capacities in relation to harvest operations.
APPROACH: Investigate the use of solar energy as drying shelled corn in bins on farms. Design and develop solar energy collection and storage devices applicable to grain drying systems. Investigate low temperature drying and combinations of heated air and low temperature drying as methods of reducing the energy required for drying corn. Investigate methods of extending the allowable time for low temperature and unheated air drying, including chemical treatment and intermittent removal of small amounts of moisture. Conduct pilot and full-scale tests of promising drying and conditioning methods and determine capacity in relation to production and harvest operations.
PROGRESS: Two experiments of corndrying using solar energy are in progress. A combination desiccant flow temperature system is being field tested and computer simulated. Corn overdried to under 9% moisture was mixed with wet corn at harvest. A 20% moisture mixture was dried in a low-temperature drying system. A 15.5% moisture mixture was placed in storage. Computer simulation is being used to determine collector size and airflow rate for desiccant preparation. A corndrying system has been fitted to an existing 232 m(2) air collector designed for heating a school gymnasium near West Branch, Iowa. During Fall 1979 about 147 t of corn was stir-dried from 21.6 to 16% moisture using solar heated air.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0071
SOLAR ENERGY GRAIN DRYING HANDBOOK
Pedersen JH, Hartsock JG, Dept. of Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (3091-20592-029A(1))
OBJECTIVE: Complete a handbook to be one of the Midwest Plan Service Series to be entitled "Solar Energy Grain Drying Handbook", as authorized by the Midwest Plan Service Committee.
APPROACH: Resolve remaining differences concerning content of the near-final draft, polish the manuscript and drawings, set type, prepare ink drawings, and prepare camera-ready copy for photo-offset printing. Print 1500 copies of the completed Handbook for distribution as designated.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0072
COMPARATIVE INVESTMENTS, COSTS, AND RETURNS FROM ALTERNATIVE SWINE PRODUCTION SYSTEMS
James SC, Dept. of Economics, Iowa State University, *Ames, Iowa, 50010,* (IOW02392)
OBJECTIVE: Define representative production systems, build investment requirements and coresponding labor requirements, develop fixed and variable cost estimates, consider the effect of size, prices planning horizon and energy restraints; study the economics of herd replacement.
APPROACH: Review similar studies including a former survey of Iowa producers, consider additional producer surveys. Obtain investment data from commercial business firms, records of recent farm investment and construction cost estimates, tabulate fixed costs using standard procedures. Variable costs will be developed from animal performance data from research scientist and farm producers. Simulate the effect of price and energy changes upon income and investment repayment and returns. Use discounting and costs and returns principles to evaluate sow replacements.
PROGRESS: Research has begun on the economics of alternative sources for heating swine production facilities. Solar heat is one option being considered. This study is new and still in the data gathering stage so no results are available.
SUPPORTED BY: Iowa State Government.

1.0073
IMPROVED SYSTEMS FOR GRAIN HARVESTING, DRYING, CONDITIONING, AND STORAGE ON FARMS
Kline GL, U.S. Dept. of Agriculture Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (3408-20590-001)
OBJECTIVE: Investigate improved systems for harvesting, drying, conditioning, and storing corn on farms to reduce energy use and cost, maintain quality, and provide suitable system capacities.
APPROACH: Use systems analysis to develop models for complete systems of corn harvesting, drying, conditioning, and storage. Develop computer simulation programs to compare representative farm drying systems such as continuous flow, batch-in-bin and continuous flow in bin. Analyze systems that use renewable sources of energy such as solar grain drying, low temperature drying, and appropriate combinations. Investigate systems for using crop residues for drying shelled corn with heated air. Develop systems for harvesting, transporting, storing and producing energy from corn crop residues. Investigate methods of energy conversion including direct burning, pyrolytic decomposition, and methane generation. Construct pilot-scale equipment and measure useable energy content of crop residues. Develop integrated systems for harvesting, drying, and storing corn that emphasize reduced energy requirements and efficient operation on different size farms.
PROGRESS: Two computer models, CORNSIM and FALDRY, were developed and used to conduct a simulation study of corn production and low-temperature drying for Central Iowa conditions. CORNSIM simulates a complete corn production enterprise of planting, crop development, yield and harvesting. FALDRY simulates a system of low-temperature corn drying bins. FALDRY inputs include bin specifications, weather data and the incoming flow of harvested grain. FALDRY predicts the success or failure of a low-temperature corn drying system and the amount of electrical energy used. The following conclusions are given for Central Iowa conditions and would be expected to be similar for most of the Corn Belt: (1) The most efficient method of using electrical energy to increase drying rate, improve the probability of drying in the fall and reduce grain deterioration is to increase fan power: (2) If the daily harvest rate is 1/16 or less of the total production, it is feasible to match the capacity of corn harvesting and low-temperature drying systems. (3) Design criteria and management strategies are recommended for low-temperature corn drying systems.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0074
SOLAR ENERGY FOR CORN DRYING ON FARMS
Kline GL, U.S. Dept. of Agriculture Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010*, (3408-20590-002)
OBJECTIVE: Design and develop techniques and equipment for collecting, storing, and utilizing solar energy for drying shelled corn on farms.
APPROACH: Develop solar energy collection devices based on present knowledge and incorporate new findings on methods and materials. Design and develop solar energy storage techniques and equipment to utilize solar heat in grain drying systems. Adapt computer simulation models to predict energy collected and drying potential based on grain deterioration rates and weather records.
PROGRESS: Five multiple-use solar collectors were tested during the fall grain drying season. Variable speed fans were used to obtain data for airflow rates of 2 to 24 cubic feet per minute per square foot of collector area. Air volume was measured with a a calibrated 10" Ellison Annabar and Meter. Solar insolation was measured with a tracking pyroheliometer (direct insolation), a collector mounted pyranometer (incident solar insolation) and a horizontal pyranometer (total insolation by calculation). Temperatures were recorded for outside air, collector inputs, and collector outputs. Collector efficiency (instantaneous) was determined as the useful energy collected divided by the solar energy incident upon the surface of the collector and recorded during the noon hour. For grain drying at a low-temperature rise, the multiple-use collectors were operated at a high airflow and in the suspended-plate configuration with an efficiency range from 49 to 64%. For water heating and space heating with a moderate temperature rise, the multiple-use collectors were operated at a low airflow and in a single channel configuration with all the air under the absorber with an efficiency range from 39 to 58%. Papers were presented on solar collector performance, solar collector costs, and a simulation model of suspended plate solar collectors. A conference on solar grain drying was organized and held at Iowa State University. Information was furnished for preparation of a solar grain drying handbook.
SUPPORTED BY: U.S. Dept of Agriculture, Agricultural Research.

1.0075
VACUUM DISTILLATION OF FUEL ALCOHOL USING SOLAR ENERGY
Holden ML, Smith TF, Dept. of Energy Engineering, University of Iowa, *Iowa City, Iowa, 52240*
OBJECTIVE: To determine the economic and energy feasibility of on-farm to farm coop size fuel alcohol production plants that utilize vacuum distillation and solar energy.
APPROACH: Design, build, and test a solar assisted vacuum distillation unit, and analyze the experimental results in the categories of; energy balance, useful energy gain from solar collectors, time and effort requirements of the production system, rate and proof of production, and the collector area to production rate ratio.
PROGRESS: Experiments with a batch vacuum distillation unit which used solar energy proved the energy efficiency of combining vacuum distillation and solar energy. Utilization of vacuum distillation allows for operation of the collectors at low temperatures yielding high collector efficiencies and the use of low cost flat plate solar collectors. The need for a constant high proof product necessitated the switch to a continuous distillation process. A thirty foot long, four inch diameter continuous distillation column, and a 200 square foot collector array are being constructed with operation anticipated by January 1981. Initially, a constant temperature heat source will be used to investigate the vacuum distillation process, and then water heated with solar energy will serve as the heat source. The engineering parameters of vacuum distillation and solar energy will be determined independently.
SUPPORTED BY: Iowa State Government.

1.0076
ASSESSING SOLAR ASSISTED FUEL ALCOHOL PRODUCTION IN THE STATE OF IOWA
Smith TF, Holden ML, Dept. of Energy Engineering, University of Iowa, *Iowa City, Iowa, 52240*
OBJECTIVE: To improve the State of Iowa energy self-sufficiency through the use of solar energy to produce fuel alcohol.
APPROACH: To determine the role of solar energy in fuel alcohol production from on-farm to commercial scale production sizes, four categories of research will be pursued: 1) field survey of on-farm to large commercial scale operators, 2) library research of pertinent literature, 3) experimentation at The University of Iowa, and 4) engineering analysis of existing and conceptual alcohol production facilities which utilize solar energy.
PROGRESS: Several fuel alcohol producers have been interviewed for their experiences and advice. Previously published literature on solar assisted fuel alcohol production is being reviewed. Solar insolation, corn production and prices, and rainfall have been examined over a several year period for input to solar assisted fuel alcohol feasibility. A 200 square foot collector array and a four inch continuous vacuum distillation column will be interfaced and on-line for generating experimental data. Criteria for analyzing fuel alcohol production facilities have been established and input data are being sought.
SUPPORTED BY: Iowa State Government.

1.0077
SOLAR ENERGY FOR GRAIN DRYING
Lipper RI, Dept. of Agricultural Engineering, Kansas State University, *Manhattan, Kansas, 66502*, (KAN-05-398)
OBJECTIVE: Evaluate performance of inflatable plastic tubes as solar collectors; correlate performance of collectors with weather; establish effectiveness of supplementing natural air with solar heat for drying grain; study installation methods, maintenance problems, serviceability of collectors.
APPROACH: Two "Helio" solar collectors will be used to acquire data on corn and grain sorghum drying in two metal bins where natural air is supplemented with solar heat. Two similar bins will be dried with natural air. Continuous air flows, 2 to 3 cfm per bu, will be used on 20% moisture grain sorghum and 20% moisture corn. Observations include initial and final moisture, weight, test weight and mold count. Temperatures, moistures, air flows and static pressures will be monitored. Weather data, air temperatures for changes across the collectors fans and grain bed, and power consumption will be measured or recorded.
PROGRESS: A grain bin complete with drying system, bottom unloading auger, and recirculating auger was erected close to a swine farrowing building that has a successful experimental solar collector-heat storage wall on its south side. The collector is ideal for the dual uses of preheating ventilation air for the building and providing supplemental heat for low temperature grain drying. The bin is connected to the collector by a 15-foot long, insulated duct with dual channels - one to carry air from the collector and the other to carry ambient air to the drying fan inlet. Air dampers permit mixing in various proportions or cutting off the collector completely. The collector is 50' x 8' and the 18'7" bin holds 3000 bushels. Firm purchase contracts could not be consumated until we had firm approval on the research contract and, with last fall's grain bin sales sky rocketing as a result of the federal assistance program, delivery of all equipment came too late to accomplish drying. Test and measurements with the fully insturmental collector and dry grain in the bin are being made to predict performance through computer simulation. Actual drying tests will be conducted next fall.
SUPPORTED BY: Kansas State Government.

1.0078
DESIGN PARAMETERS FOR OPTIMUM ENVIRONMENTS IN CONFINEMENT SYSTEMS FOR LIVESTOCK-ENERGY-USE EFFICIENCY
Spillman CK, Dept. of Agriclutural Engineering, Kansas State University, *Manhattan, Kansas, 66502*, (KAN00837)
OBJECTIVE: Develop, validate, and use a dynamic simulation model, of the internal temperatute and humidity environment in an animal shelter; predict the influence of outside weather, effect of different building features, and location of heat exchanger surfaces, and scheduling of animals into structures. Possible reduction in electrical energy or fuel will be estimated.
APPROACH: Simulation model used to predict the performance of a solar swine farrowing house will be expanded. Verification will involve using swine buildings instrumented for measuring inside temperature and humidity, outside climatic conditions, and operation of fans and furnaces. Actual weather data will be used to predict the effect of various building features and scheduling animals. Performance of ventilating systems will be experimentally evaluated and modelled.
PROGRESS: The basic objectives of research covered by this project were evaluated and a new proposal submitted to initiate work on energy use efficiency in animal shelters. Efforts will now be directed toward evaluating the effect of changing the building, the physical plant, and animal management on input of fossil fuel energy to maintain environmental conditions in a farrowing building. The simplified model for simulating environmental conditions in a farrowing house that had been developed in an earlier project was modified and calibration started to compare results with data from a commercial building. Additional work continues on improvement and calibration of the model. A literature review on natural ventilation was initiated so a simulation model for airflow through a chimney could be developed. This will be continued during the coming year to evaluate the problems and benefits of using a chimney or other apparatus to provide air exchange.
SUPPORTED BY: Kansas State Government.

1.0079
INCREASED USE OF SOLAR ENERGY BY COMBINING GREENHOUSE AND ANIMAL SHELTER
Spillman CK, Butler JL, Dept. of Agricultural Engineering, Kansas State University, *Manhattan, Kansas, 66502*, (7011-20690-024-A)
OBJECTIVE: Develop, test, and demonstrate increased utilization of solar energy by combining greenhouse and animal shelter for increased insulation and conservation of energy.
APPROACH: Design, construct, operate, and evaluate two identical 20' x 24' greenhouses attached to the south side of farm buildings, one used as a conrol and attached to an unheated building, the second attached to a hog farrowing house. Air will be circulated between greenhouse and hog house for use of animal heat and CO(2) enriched air in the greenhouse. Solar heated air in the greenhouse will be circulated through rock for thermal storage of excess heat. Production and acceptability of tomatoes and cucumbers will be determined.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0080
SOLAR ENERGY SYSTEM FOR AGRICULTURE
Parker BF, Dept. of Agricultural Engineering, University of Kentucky, *Lexington, Kentucky, 40506*, (KY00129)
OBJECTIVE: Determine the solar radiation concentration, conversion of solar radiation to heat and the heat transfer characteristics of a focusing solar energy collector. Determine feasible outlet temperatures and the corresponding solar energy recovery efficiency of an improved flat plate and focusing solar energy collector.
APPROACH: A focusing collector and a flat plate collector will be constructed-both have unique features which show promise for increasing the collection temperature and/or efficiency. Air will be used initially as the transport fluid with a rock bed for storage. Data from the test will be used to determine the efficiency and output temperature as well as heat transfer characteristics of the collectors. The latter knowledge will be used to improve the design. A computer simulation of the collector, storage, and load will be developed.
PROGRESS: This project has developed a sun-tracking, focusing collector and flat-plate solar air heater. Some work has been accomplished on storage of solar heat in crushed limestone. The focusing collector was designed mainly for heating ambient air. The air heating focusing solar collector performed at efficiencies between 49 and 57% while heating ambient air to temperatures in the range of 250 to 350 degrees F. Several designs for

vee corrugated flat-plate collectors have been constructed and tested. Two of the general collector types; namely, flow on both sides of the absorber and flow underneath the absorber have been developed as usable designs. Three full scale units have been installed following these designs. In addition, a heat transfer analysis of collector heat flow has yielded some basic design equations for predicting the performance of flat plate solar air heaters. These equations form the basis for designing solar air heaters.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0081
HIGH TEMPERATURE GRAIN DRYING USING SOLAR ENERGY
Parker BF, Hartsock JG, Dept. of Agricultural Engineering, University of Kentucky, *Lexington, Kentucky, 40506,* (3090-15703-020C)
OBJECTIVE: Determine the technical and economic feasibility of a high temperature grain drying system that uses solar energy.
APPROACH: Design a new receiver for the focusing collector to increase collector efficiency above current 35-50% levels by improving the accuracy of the aluminum fins, by reducing the size of the central glass pipe to three inches, and using a single glass pipe instead of two. Investigate two possible methods for improving the rock bed: compare heat transfer characteristics and pressure drops of stone beds with a broader range of stone sizes than the present beds, and investigate methods to reduce heat transfer between adjacent rock-bed compartments to sustain higher temperatures. Conduct a combination high-temperature/low-temperature drying test using low-level heat from the rock-bed for the low-temperature phase and develop a computer simulation of this type of system. Test the principle of using exhaust air to reduce the temperature of incoming drying air as a means for reducing over-drying. Continue refinement & validation of the modeling of the system.
PROGRESS: A high-temperature focusing collector has been designed and constructed and an associated rock-bed storage evaluated for heat-transfer and air-flow characteristics. Grain bins will be constructed to complete the system for use in the next phase of the project. An economic analysis of high-temperature solar grain drying was made, concluding that the process is not economically feasible at prevailing prices for LP gas.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0082
EVALUATING ENVIRONMENTAL CONDITIONS FOR CURING BURLEY TOBACCO
Walton LR, Ross IJ, Bridges TC, Dept. of Agricultural Engineering, University of Kentucky, *Lexington, Kentucky, 40506,* (KY00145)
OBJECTIVE: Develop and evaluate a model to predict the environmental conditions within tobacco barns during curing. Use the model to evaluate the need for environmental modification on tobacco curing barns to minimize adverse effects of weather.
APPROACH: A heat, moisture, and mass balance will be used to develop a three-dimensional-deep-layer-drying analysis of burley tobacco curing within a tobacco barn. The model will include the effects of outside temperature, humidity, windspeed and direction, and solar heating of the roof. Input data needed by the model will be determined from the literature or by experimental observations in curing facilities. The output of the model will be compared to the actual environmental conditions which occurs within a burley curing barn.
PROGRESS: A mathematical model to predict temperature, relative humidity and leaf moisture content within burley tobacco curing barns has been developed. The model is three dimensional to account for wind direction and solar heating of the roof as well as drying. A paper was prepared and delivered to the American Society of Agricultural Engineers on the development of the model. A paper on validation of the model is being prepared. Validation of the model is two-fold. The first comparison will be with temperature and humidity data collected by instrumenting an experimental solar curing facility. The second comparison will be to data from a two-tier forced-ventilation barn.
SUPPORTED BY: Kentucky State Government.

1.0083
CURING BURLEY TOBACCO
Henson WH, Walton LR, U.S. Dept. of Agriculture, Agricultural Engineering Res. Div., University of Kentucky, *Lexington, Kentucky, 40506,* (7809-20881-002)
OBJECTIVE: Determine the response of Burley tobacco to environmental control of temperature, humidity, and air flow during the early stages of drying; to develop economical curing systems with predictable control of leaf color, chemical change, moisture content, and other physical properties; and to develop curing systems which will facilitate mechanization of harvesting and handling.
APPROACH: Consider the complex biochemical changes in the Burley tobacco plant during curing process. Study plant response (color, chemical change, moisture content, gaseous exchange to curing environment (air velocity, temperature, closeness of packing). Determine degree of leaf damage from adverse environmental treatments; determine degree to which adverse affects of environment may be reversed by subsequent environmental treatments.
PROGRESS: The solar curing barn was used to bulk-cure burley with 100 solar energy for drying. Humidity control was used to prevent overdrying. However, a circulating fan failed in the first test and caused damage from underdrying. The second curing test was unsatisfactory due to cool weather during the last season. Quality of burley tobacco was evaluated by chemical analyses, moisture uptake, burn rate, filling value, and microbial counts on tobacco at various stages of curing and storage. Moisture desorption is about three times faster than moisture sorption for the same environmental conditions. Filling value of shredded tobacco appeared to be independent of loading rate up to 100 cm/min of piston velocity. Chemical analyses indicated that harvest date (maturity) and stalk position (priming) had the greatest influence on 10 chemical components. Also, underdrying during the yellowing and browning stages of curing significantly reduced total sugars in the cured leaf. Bacterial populations increased rapidly during high-temperature, high-humidity curing. Counts were higher for controlled laboratory curing than for barn curing. Storage tests at 85 degrees F and 87% and 92% relative humidity showed that bacterial and fungi counts increased with humidity. Chemical analyses will be used to assess bacterial and fungi damage to the tobacco.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0084
DRYABILITY OF HARDWOODS BY SOLAR-HEATED AIR AND ITS RELATIONSHIP TO PERMEABILITY
Choong ET, Agricultural Experiment Station, Louisiana State University, *Baton Rouge, Louisiana, 70803,* (LAB01440)
OBJECTIVE: Determine the effect of steaming on permeability and dryability. Construct and evaluate a small forced-air solar dryer for drying hardwoods; relate climatic and solar energy data to drying of wood in Louisiana; compare the results of solar drying with conventional air and kiln drying, in terms of permeability and dryability; develop a technique of accelerating the drying of refractory hardwoods with high temperature by first predrying in a solar kiln; review the state-of-the-art of solar energy collection and solar drying for application to wood processing.
APPROACH: Determine effect of steaming on permeability, dryability and shrinkage of several species and wood-types; construct a forced-air solar kiln; compile local climatic data relevant to the solar kiln. Dry several species of wood by kiln-drying at high and moderate temperatures, , air-drying, and solar-drying. Drying lumber-size material in a drying charge. Review the state-of-the-art of solar drying.
PROGRESS: A new approach, differing from the traditional greenhouse solar drier, was attempted to solve problems related to solar lumber drying. An experimental solar kiln was designed with an innovative solar collector and a different approach to drying methodology and solar heat storage. The "box-type" solar collector design has improved optical and heat transfer capabilities and flexibility for seasonal optimization compared to traditional flatplate collectors. Testing of the solar kiln involving 6 charges (i.e., 51 mm thick ash, 51 mm hackberry, 38 mm red oak, 25 mm ash, 25 mm cypress, and 38 mm red oak) indicates solar drying can be 2.5 to 3.5 times faster than air drying in Louisiana. Solar drying would, therefore, seem to be a good method of predrying refractory woods, resulting in faster drying rates with low fuel cost. Solar drying can also be used to reach lower (i.e., 8 MC) necessary for interior millwork. The quality of solar-dried wood is good. A detailed project analysis of three solar kiln sizes--48,690, 64,920, 81,150cubic meter--indicates that a solar kiln is both technically and economically feasible. Cash flow analysis indicates the proposed project would yield a favorable rate of return.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0085
WATER SOURCE HEAT EXCHANGE FOR HEATING AND COOLING IN AGRICULTURAL AND RURAL RESIDENCE USE
Braud HJ, Dept. of Agricultural Engineering, Louisiana State University, *Baton Rouge, Louisiana, 70803,* (LAB02061)
OBJECTIVE: Evaluate new thermal energy flow systems with energy exchange to atmospheric, earth, ground water, and fabricated storage media, with solar energy collection and nocturnal heat refection for use with water source heat pumps. Survey ground and surface water supplies and soil temperatures in Louisiana for potential thermal energy exchange. Survey existing water-cooled heat pump installations in rural areas to ascertain installation, maintenance, and operating costs and identify operational problems. Evaluate water-source heat pumps and auxillary epuipment for improved energy efficiency in space heating and cooling in rural residence use.
APPROACH: Computer prediction models will be made to quantify energy use in water-cooled heat pump systems with several modes of energy cycling for farmstead and rural residence use. Heat transfer to earth grid, ground water, and surface sources will be evaluated for energy conservation. Laboratory and on-site studies of the more viable heating and cooling systems will be done to verify computer prediction model.
PROGRESS: Computer prediction models were used to calculate annual energy consumption for both air and water source heat pumps at New Orleans, Baton Rouge, and Shreveport, La.; Little Rock, Ark.; Kansas City, Kan.; and Sioux City, Iowa. The models gave a direct comparison of annual energy consumption for water and air source heat pumps of different efficiency ratings and predicted the effect of source temperature on energy consumption. Energy cost savng potential with solar heating of the water and a buried earth grid was also investigated. Optimum year-round water temperature is 10 degrees C at New Orleans, 12 degrees C at Baton Rouge, 16 degrees C at Shreveport, 24 degrees C at Little Rock, 32 degrees C at Kansas City and more than 36 degrees C at Sioux City. At New Orleans the well water temperature is 24 degrees C and is relatively warm at a location where the cooling load is much larger than the heating load. At Shreveport the two loads are nearly equal, and well water is near ideal. At New Orleans energy consumption was 11,703kwh (solar-plus-well) versus 12,291 kwh (well only) at 4 tons. Solar augmentation with ground water cooling offers the highest potential for energy economy at all locations.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0086
SOLAR ENERGY AS SUPPLEMENTARY HEAT FOR GRAIN DRYING
Mayeux MM, Wratten FT, Stipe DR, Dept. of Agricultural Engineering, Louisiana State University, *Baton Rouge, Louisiana, 70803,* (LAB01890)

OBJECTIVE: To accumulate data on locally available solar energy, and to determine efficient method of collecting and storing this energy for optimum use for grain drying. To determine rates of energy storage and retrieving from a medium such as rock or water under various conditions of air flow and to develop management techniques for operating a solar dryer. To develop methods of applying solar energy to the distillation of alcohol.
APPROACH: Data available from the literature and applicable to grain drying will be accumulated. Additional data will be developed. A low cost collector will be constructed and tested. Air flow rates will be varied to optimise heat collection. The production of drying potential (C.F.M.of low RH air)will be measured. A storage bed of rock will be evaluated for energy storage and retrieval. Thermal conductivity, specific heat and surface conductance coefficient of Louisiana rock will be determined. A small scale collector, energy storage bed and dryer will be built and tested to determine energy production rates needed for designing solar dryers. A flat plate collector using water as the collection medium will be instrumented to determine the quality and temperature of water produced by the unit. This will be fed to a focusing collector to bring it up to 200 degrees F. The distillation process will consist of temperature and vacuum. Using this combination, minimum energy requirements for alcohol production will be determined.
PROGRESS: Two bare plate collectors were used with a channel depth of 1.59 cm, an area of 2.97 m (2) and a flow passage length of 7.32 m. The absorber was blackened aluminum roofing. Orifice plates metered the air into and out of the collectors and the rock thermal storage bin. Accurate flow rate measurements were shown to be critical by a simulation of the rock storage. Two model-size deep bin dryers 25.4 cm in diameter and 2.54 m deep were instrumented with thermocouples every 10 cm. Air flow rates of 0.07 m(3)/min/bu were used. Dryer 1 operated directly from a collector with a humidistat controlled fan set at 80% RH for two trials and operated continuously for 2 trials. Dryer 2 received air continuously from a collector and rock bed in series. Based on 4 drying tests with rice there are no significant differences in the time required to dry rice when both fans ran continuously.
SUPPORTED BY: Louisiana State Government.

1.0087
ASSESSMENT OF TECHNOLOGY IN THE FOOD AND FIBER SYSTEM
Miller, ME, National Economic Div., U.S. Dept. of Agriculture, Economics & Statistics Service, *New Orleans, Louisiana, 70179,* (NEA-12-107-22-08)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra- and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Solar energy applications research continued with data gathering and consulting with SEA/AR and SAES engineers. The major applications were tobacco irrigation, peanut drying, and greenhouse heating. Solar powered irrigation was also studied but not as intensely as the other areas. The feasibility of feeding crop residues to beef cattle was studied. The study inventoried residues on a county-by-county basis, estimated the economic values of residues, and identified the economic effects of reducing grains and increasing forage and residues. Data was gathered to compare trends in technology and productivity in processing and distribution. Uses of agricultural products in manufactured goods were identified.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

1.0088
INTEGRATION & EVALUATION OF FORAGE PRODUCTION, HANDLING, AND UTILIZATION
Rowe RJ, Dept. of Agricultural Engineering, University of Maine, *Orono, Maine, 04469,* (ME08034)
OBJECTIVE: Evaluate harvesting and processing systems for immature forages.
APPROACH: Using forage materials harvested at pre-boot and early bud stages as provided by Department of Plant Sciences under companion project, forage will be field cured to approximately 40% moisture, artificially dried at differential temperatures and pelleted. Continuous flow drier will be tested at differential time and temperature rates, pellets evaluated for milling size, durability, and compared with non-pelleted samples, for samples, for nutritional value. Energy requirements will be determined. This is a companion project with Plant Science, Animal Science, and Agricultural Economics to determine feasibility of producing, harvesting, feeding immature silage for ruminants.
PROGRESS: Immature forages were prepared for evaluation as concentrate substitutes for ruminants. Early harvests of Timothy and Alfalfa were partially field dried and finish dried with heated air at 60 C. These harvests were subsequently fed to sheep to evaluate digestibility. Additional harvests were finish-dried with solar heated air with daily cycling temperatures, peaking at about 45 C, demonstrating the feasibility of producing heat dried forage without fuel input. Input data was prepared for the NE-111 comprehensive forage system analysis model. Equipment was selected by type and size and man and machine operating times and fuel requirements were estimated for the various field operations. These and other cost data used in the model were reviewed and adjusted to correspond to Northern New England conditions. Literature review and preliminary work has been done to develop a component simulation model describing losses in quantity and changes in quality of forage crops from the beginning of harvest through the end of storage. This is part of a cooperative effort to extend the usefulness of the NE-111 comprehensive forage system model.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0089
SOLAR ENERGY FOR MILKING PARLOR HEATING AND COOLING
Thompson PD, Animal Physiology and Genetics Institute, U.S. Dept. of Agriculture, Federal Research Office, *Beltsville, Maryland, 20705,* (1106-20401-001)

OBJECTIVE: Develop technology and demonstrate the feasibility of using waste heat recovery, load reduction, and solar energy to reduce the electrical and fossil fuel requirements for operation of milking parlors for dairy production.
APPROACH: Solar energy collectors will be specified, procured or constructed, and installed on appropriately modified structures for capture of heat energy. Insulated hot water storage tanks will be constructed to store this energy over diurnal and short-term climatic cycles. Additional heat will be recovered by scavenging waste heat from refrigeration compressors and vacuum pumps. The heat energy thus obtained will be used to reduce the electrical energy required for water and space heating and for milk cooling. Non-thermal load reduction will be achieved by developing lighting and milking systems of improved efficiency. System flexibility will be sufficient to accept heat or mechanical energy from wind power if such a project is subsequently established at this location.
PROGRESS: An operating solar heating system has been constructed in the milking parlor at the Beltsville Agricultural Research Center. Approximately 20 square meters each of four types of flat-plate solar collectors are used. The types are: open-channel, non-selective, single glazed; closed channel, non-selective, double glazed; closed channel, selective, single-glazed; and closed channel, selective, double glazed. Heat storage is a 37,000liter insulated concrete in-ground tank. Heat is used for domestic water pre-heating by a tube-in-shell heat exchanger and for milking pit space heating by floor-mounted plate heaters. Each heat source and heat using device is monitored by thermocouples and flow meters. Data is automatically collected, linearized, integrated, and stored by a programmable calculator which controls and reads a scanner and digital multimeter. The circulating fluid is corrosion-inhibited water. Aluminum collectors are further protected from corrosion by passing their supply water through a packed column of aluminum wool. The system began operation in spring of 1976 and has run continuously since. About one half of the heat energy demand of the targeted loads in the milking parlor is now being supplied by solar heat. (4 x 108 J/day). Major problems have been large heat losses from the storage tank.
SUPPORTED BY: U.S. Dept. of Agriculture, Federal Research Office.

1.0090
APPLICATION OF SOLAR ENERGY TO AGRICULTURE
Altman LB, U.S. Dept. of Agriculture, *Beltsville, Maryland, 20705*
Summary information has not been provided.
SUPPORTED BY: U.S. Dept. of Energy.

1.0091
UTILIZATION OF SOLAR ENERGY IN BROILER PRODUCTION
Cain JL, Felton KE, Thomas OP, Dept. of Agricultural Engineering, University of Maryland, *College Park, Maryland, 20740,* (MD-RAM-049)
OBJECTIVE: Determine fossil-fuel savings by introducing heated air from a solar collector directly into the ventilation air inlet of a broiler facility with excess heat going to rock storage. Retrofit a broiler facility using the roof as a solar collector. Study the physiological response of broilers to determine if introducing heated air from a solar collector significantly affects their behavior or performance. Conduct an economic analysis to determine cost-benefit ratios for the system.
APPROACH: The solar system of the research facility will be modified to replace the water storage of energy with rock storage of energy. The duct work will be modified so that the warm air will enter the ventilation system and/or pass through the rock storage unit. A second test chamber will be modified to add a collector to the roof and take the heated air directly into the ventilation system. Storage will not be provided.
PROGRESS: There were no major changes made in the solar research facilities during the past year. One change that should improve the results in the system without storage was made. In fact improved results are showing in a test that is now underway. Full coverage will be given in the next report. Results from the tests run on the rock storage indicate that for (1) a given air flow rate the pressure drop per meter of storage length increases linearly, (2) for the range of air flow rates considered, electrical power usage increases linearly with increased air flow rates. Also, (1) pressure drop across the rock storage varies as the square of the apparent velocity, i.e.,: Delta P ≤ 2.3 x 10 - 3 (V) 2; (2) thermal stratifications along the centerline of the rock storage increased as air flow rate decreased; and (3) thermal stratification increased from the centerline perpendicular to the direction of air flow as the air flow rate decreased. Although a strict quantitative analysis was not presented, a quantitative analysis indicated that for the four air flow rates considered, the solar panels covered with glass and Tedlar retained a larger percentage of energy collected than the panels with two layers of glass. Infrared photographs indicated no significant heat loss occurred within the total system except the front of the collector.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0092
UTILIZATION OF SOLAR ENERGY IN BROILER PRODUCTION
Felton KE, Winter DW, Dept. of Agricultural Engineering, University of Maryland, *College Park, Maryland 20740,* (7006-20400-018-A)
OBJECTIVE: To prove the concept of using solar energy with and without energy storage to heat ventilating air of brooding shelters.

APPROACH: Data will be collected from a flat-plate solar collector and rock storage system and from retrofit air collector without storage. Data will be analyzed to compare operation, economy, and feasibility for limited area brooding of broiler chickens.
PROGRESS: There were no major changes made in the solar research facilities during the past year. One change that should improve the results in the system without storage was made. In fact, improved results are showing in a test that is now underway. Full coverage will be given in the next report. Results from the tests run on the rock storage indicate that for (1) a given air flow rate the pressure drop per foot of storage length increases linearly, (2) for the range of air flow rates considered, electrical power usage increases linearly with increased air flow rates. Also, (1) pressure drop across the rock storage varies as the square of the apparent velocity, i.e., Delta P = 2.3 x 10 - 3 (V) 2, (2), thermal stratifications along the centerline of the rock storage increased as air flow rate decreased and (3) thermal stratification increased from the centerline perpendicular to the direction of air flow as the air flow rate decreased. Although a strict quantitative analysis was not presented, a quantitative analysis indicated that for the four air flow rates considered, the solar panels covered with glass and Tedlar retained a larger percentage of energy collected than the panels with two layers of glass. Infrared photographs indicated no significant heat loss occurred within the total system except the front of the collector. An economic analysis showed that the cost of heat for facilities using a system of limited area brooding and conventional heating was $13.53 per thousand whereas for the solar system it was $54.43.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0093
QUALITY HOUSING ENVIRONMENT FOR LOW-INCOME FAMILIES
Fish GS, School of Human Ecology, University of Maryland, *College Park, Maryland, 20742*, (MD-Y-011)
OBJECTIVE: Identify housing related aspirations, expectations, needs and satisfactions of low income families and examine limitations to the attainment of quality housing. Develop and determine the acceptability and economic feasibility of innovative designs including housing components, new combinations of materials, and building techniques, such as peripheral heating systems and modular panels.
APPROACH: Two hundred Maryland families living in three bedroom FHA approved houses will be interviewed. Housing characteristics will serve as basis of comparison for innovative design, including housing components, new combinations of materials and building techniques, such as peripheral heating systems and modular panels.
PROGRESS: Results of the survey administered to determine the satisfaction of rural families with their housing environment show: 1) The incidence of deficiencies in the housing experienced by Maryland residents of the Benchmark houses chosen for the survey is generally lower than that of the national sample of households at the same income levels in all types of rural housing; 2) The Benchmark house could benefit from modifications to increase inside and outside storage and the overall size of the home, and to decrease utility bills; 3) Materials or construction methods for walls and ceilings should be improved; 4) Analysis of the cost of housing as a percentage of income suggests that the cost of utilities should be lowered. Although solar attic heating systems have been installed in 15 Benchmark houses in response to the findings regarding high utility costs, conclusions as to possible reductions in utility costs are not yet available.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0094
IMPLICATIONS OF DEMAND, STRUCTURE, AND ENERGY CHANGES FOR THE NEW ENGLAND BROILER AND EGG INDUSTRIES
Christensen RL, Cept. of Food & Resource Economics, University of Massachusetts, *Amherst, Massachusetts, 01002*, (MAS00393)
OBJECTIVE: To estimate the energy use and the implications of high cost energy to the production and marketing of broilers and eggs.
APPROACH: Energy input-output parameters will be estimated for broiler and egg operations in the northeast using budgeting techniques. Alternative production and marketing systems will be identified and compared with respect to energy use. Alternative energy sources will be examined and evaluated with respect to cost and efficiency. Energy costs will be placed in the context of cost of production and competitive position.
PROGRESS: An economic analysis of the feasibility of a flat plate collector solar brooding system for broiler operations in Northern New England was completed. A net present value analysis was performed incorporating such factors as fuel inflation rates, different sized collector areas, alternate discount rates, etc. Results indicated positive returns from the solar system occurred only when fuel inflation rates were extremely high. Publication of results as an Experiment Station bulletin should result in Summer 1980. Producer packers of eggs in Massachusetts were surveyed with respect to marketing practices and energy use in grading, packing and distribution operations. A complete analysis is not available at this date. A preliminary analysis of data from 25 producer packers found that 60% had weekly volumes of less than 200 cases and had grader packers with hourly capacities less than 20 cases. Producers with larger volumes washed and handled higher proportions of total volume. Smaller firms tend to sell a higher proportion of total volume as loose packs. Producer packers maintain a diversity of clientele including direct sales to consumers, wholesalers or jobbers, chain and non-chain food stores, and institutions. Analysis of survey results should be accomplished by the Summer of 1980 and publication of results should occur in late 1980.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research.

1.0095
USE OF SOLAR ENERGY PRODUCED WATER ACTIVITY DEFICIT FOR FOOD PROCESSING
Swartzberg HG, Berry RE, Dept. of Food Engineering, University of Massachusetts, *Amherst, Massachusetts, 01002*, (7006-20510-022-A)
OBJECTIVE: Investigate economic and technical feasibillty of a new energy system based on "water activity deficit" for collecting, storing and using solar energy for food processing purposes, i.e., concentration, cooking, pasteurization, blanching and drying.
APPROACH: Design solar collectors and associated equipment to concentrate calcium chloride and other desiccant solutions, and use such solutions for food processing operations. Use heat of condensation from water absorption of these solutions, as heat source for sustaining evaporation of dehydration of liquid foods such as fruit and vegetable juices. Test possibilities of cascading vapor absorption and vapor generation in a heat pumping effect for moderate low temperature refrigeration, as well as heating. Apply such latent energy from water activity deficits, to evaporating. concentrating, heating and/or cooking-blanching of fruit and vegetable juices.
PROGRESS: A focusing solar energy collector has been constructed for concentrating calcium chloride brine solutions which will be used to concentrate liquid foods and dry solid foods by contacting vapors from the foods with the brine system. Heat pumping systems are being developed which can be used to dry refrigeration or heating systems for food processing. Projected costs for seasonal "brine-driven" liquid food evaporators and "solar-driven" brine concentrating systems are higher than present costs for evaporation using fossil fuels. However, with the rapidly increasing cost of fossil fuels, such "brine-driven" evaporation systems could be economically competitive in the near future.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0096
ENERGY-ECONOMIC INTERACTIONS IN THE NORTHEAST
Willis CE, Stevens TH, Dept. of Food & Resource Economics, University of Massachusetts, *Amherst, Massachusetts, 01002*, (MAS00459)
OBJECTIVE: Improve understanding of role of energy in our economy and use these findings to develop a model to assist the search for and the evaluation of alternative energy policies.
APPROACH: Resolve the problem of differing long-run and short-run interpretations of the cross-section and time-series data. Answer questions about weather regions are separable. Are industry/agricultural sectors separable, and are there ways to reconcile the Halvorsen-Field dilemma mentioned earlier? --Can we make the models sufficiently flexible to handle new and emerging attitudes about energy, environment, and lifestyles new and "soft energy" technologies? --Can we fit standard interfuel substitution models into a macro setting? Test the prediction power of process analysis vis-a-vis econometrics for a past time period for particular sectors including agriculture, and attempt to reconcile the approaches so that they may be legitimately combined. Provide modeling of the macroeconomic setting into which the estimated energy relationships can be fit; variables such as rate of return on capital endogenous. Estimate the impacts of various energy policies on variables other than GNP growth. Use 5 and 4 to develop a multiple goal model for the Northeast to evaluate energy policies.
PROGRESS: Three activities are underway: Formulation of econometric model of electricity demand in New England; Application of learning concepts in solar energy economics; development of data base for investigation of energy-economic interactions in New England. The literature was reviewed and summarized and empirical analysis begun. Significant findings are anticipated in 1980.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research.

1.0097
SOLAR ENERGY FOR GREENHOUSE HEATING
Feder WA, Campbell FJ, Rosenau WA, Suburban Experiment Station, University of Massachusetts, *Waltham, Massachusetts, 02154*, (MAS00429)
OBJECTIVE: This is a joint effort of Federal agencies (ERDA, USDA), State agencies (Agr. Exper. Stn.), and private industry to determine and demonstrate the practical feasibility of growing commercially important plant materials in a greenhouse heated by solar energy systems.
APPROACH: A commercial greenhouse will be retrofitted with solar energy heating units. Data will be collected and analyzed on environmental conditions, energy ratios, collection, distribution and consumption, foliage plant productivity and quality.
PROGRESS: Solar module produces more BTUs than designed storage can store. To make the system cost-effective larger storage capacity must be designed and constructed. Data to-date indicate that air inflated double-poly layers reduce light transmission at least 25%, markedly increase relative humidity resulting in reduction of quantity or irrigation water needed, fuel savings of 50-60% for heat and warming irrigation water, and require the increased production of generated CO(2) to compensate for the inability of natural replacement of CO(2) levels because of tightness of double-poly seal. The double-poly layers thus create a saving of both fuel and water. The solar module, at its present level of operation, has no impact on fuel use or plant culture.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research.

1.0098
TEST OF SOLAR POWERED ELECTROSTATIC FOODKEEPER DEVICE
Macauley BT, Advanced Systems Associates, *Bloomfield Hills, Michigan, 48033*, (ASA-1000A)
OBJECTIVE: To design, build, and proof-of-principal demonstration of an electrostatic foodkeeping device which can be powered by solar or wind energy. Program goals are: (1) conduct study to identify potential residential, commercial, and agriculture applications of the device; (2) study various design configurations to produce a pre-prototype design with low power demands; (3) build a breadboard test bed to use as a proof-of-principal demonstration unit; and (4) operate the breadboard electrostatic field foodkeeping device on solar power.
SUPPORTED BY: U.S. Dept. of Energy.

1.0099
ANIMAL HOUSING ENVIRONMENT IMPROVEMENT WITH SOLAR ENERGY
Esmay ML, Dept. of Agricultural Engineering, Michigan State University, *East Lansing, Michigan, 48823,* (MICL00981)
OBJECTIVE: Determine the feasibility of solar radiation for the supplemental heating of egg production houses in Michigan. Maintain inside house temperature at from 70 to 75 degrees F rather than the more traditional 50 to 55 degrees F. Dry poultry excreta with hot weather solar energy. Develop a simulation model for the application of solar energy to poultry housing.
APPROACH: A 1200 fg single air pass, fixed-position, glass-glazed solar collector will be evaluated for the supplemental heating of a 5000 laying hen cage-type poultry house. The solar heated air will be introduced directly into the ventilation air system of the laying house as available on sunny days. The solar heated air will help maintain the house temperature at 70 to 75 degrees F and bring about considerable dehydration of the poultry excreta while the sun shines. The excreta drying will hopefully provide a carryover effect that will keep humidity levels within a tolerable range, with reduced air exchange rates during nights and cloudy days. A computer model will be formulated and verified with these data to provide a planning tool for solar collector designs.
PROGRESS: The operational phase of the DOE/USDA solar energy application to poultry housing research project was completed following the 1978-79 winter. The rest of the 1979 year was used for data analysis. A performance study of the collector was made somewhat separately from the poultry house application phase. There was found to be essentially a direct relationship between the volumetric air flow rate and the instantaneous efficiency of the collector within the range of air flow rates observed. The air flow range varied nearly 100% from 0.37 to 0.44 m (3) /min/m (2) and the resulting efficiencies varied about the same amount from 40 to 75%. The 0.64 m (3) /min/m (2) air flow rate had a calculated maximum efficiency index of 81 percent. Collector efficiency was also found to vary with the daily insolation level. The seasonal efficiency of a fixed position collector also varies with the position of the sun. On clear days during January and February, the collector delivered between 1 and 1/2 cents worth of heat per sq. ft. of collector per day. This value was calculated on a Btu of fuel oil equivalent with oil at $1.00 per gal. 140,000 Btu/gal. and 50 percent efficiency.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0100
SUPPLEMENTAL HEATING OF LAYING HEN HOUSES AND EXCRETA DRYING IN THE NORTHERN STATES WITH SOLAR ENERGY
Esmay ML, Winter DW, Dept. of Agricultural Engineering, Michigan State University, *East Lansing, Michigan, 48823,* (7091-20401-011A(3))
OBJECTIVE: Develop and evaluate techniques for use of solar energy for supplemental heating of cage-type egg production houses in the northern states in winter, and for drying of poultry excreta produced in such houses in both summer and winter.
APPROACH: Solar energy collection system will be installed on caged layer research house to increase winter environmental temperature in house from 55 to 70 degrees F. in order to reduce feed consumption, reduce ammonia and moisture in house, and enhance drying of manure. Solar system will be used in summer to increase drying of manure produced in houses.
PROGRESS: The operational phase of the DOE/USDA solar energy application to poultry housing research project was completed following the 1978-79 winter. The rest of the 1979 year was used for data analysis. A performance study of the collector was made somewhat separately from the poultry house application phase. There was found to be essentially a direct relationship between the volumetric air flow rate and the instantaneous efficiency of the collector within the range of airflow rates observed. The air flow range varied nearly 100% from 0.37 to 0.64 m (3)/min/m (2) and the resulting efficiencies varied about the same amount from 40 to 75%. The 0.64 m (3)/min/m (2) air flow rate had a calculated maximum efficiency index of 81%. Collector efficiency was also found to vary with the daily insolation level. THe seasonal efficiency of a fixed position collector also varies with the position of the sun. After the seasonal variation is factored out, the collector was found to vary with daily insolation as YE = 1.44 + 8.69 (i)(c) -0.32X 2 (i)(c) where YE = estimated average daily collector efficiency in percent and X(i)(c) = total daily insolation received on the surface of the collector, MJ/m (2). On clear days during January and February, the collector delivered between 1 and 1/2 cents worth of heat sp. ft. of collector per day. This value was calculated on a Btu of fuel oil equivalent with oil at $1.00 per gal. 140,000 Btu/gal. and 50% efficiency.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0101
BIO-PHYSICAL FACTORS AFFECTING ENERGY REQUIREMENTS FOR POULTRY PRODUCTION
Jordan KA, Waibel PE, El Halawani ME, Dept. of Agricultural Engineering, University of Minnesota, *St. Paul, Minnesota, 55101,* (MIN-12-075)
OBJECTIVE: Develop a model to evaluate the manipulation of biological and physical systems needed to reduce feed and fuel energy costs. This will be accomplished by assessing the interactions between biological factors such as: metabolism, nutrient, behavior, reproduction, endocrine factors, infection, and physical factors such as: thermal environment, light, air quality, and confinement. Develop and evaluate new techniques for measuring physiological and behavioral responses to the environment.
APPROACH: Biological models are being verified by calorimetric tests, nutritional trials, and body composition analysis. Biological causes and constraints will be considered. Physical models including simulation of solar energy sources and perimeter losses of the building will be verified and exercise to determine viable systems. Ventilation rates are to prime importance in establishing energy efficient systems that are cost effective. Thus field tests of numerous systems will be used to document how ventilation should be managed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0102
SOLAR ENERGY FOR SUPPLEMENTAL HEATING OF TURKEY HOUSES
Jordan KA, Winter DW, Dept. of Agricultural Engineering, University of Minnesota, *St. Paul, Minnesota, 55101,* (7093-20401-013A)
OBJECTIVE: Develop design criteria for use of solar energy for heating facilities used for rearing turkeys in Northern U. S. climates.
APPROACH: Basic design parameters developed for use of solar energy in heating poultry houses will be modified and used to design a solar heating system for a turkey rearing house in Northern U. S. The system design will be tested on a turkey production facility in Minnesota.
PROGRESS: Sokhansang, S. Jordan, K.A. Weisbecker, T.L. and Jacobson, L.D. 1979. Ventilating Animal Shelters with Solar Heat. ASEA Paper No. 79-4045.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Engineering.

1.0103
SOLAR DRYING OF PEAT
McClendon RW, Dept. of Agricultural & Biological Engineering, Mississippi State University, *Mississippi State, Mississippi, 39762,* (MIS-0124)
OBJECTIVE: Design, construct, and test a solar dryer for drying Mississippi peat to a moisture content acceptable for marketing as an agricultural product. This process will be constrained to a minimum usage of fossil fuels.
APPROACH: Final design of greenhouse-type structure, design of mechanical stirrers for peat, construct concrete slab and structure, test solar dryer under various weather conditions from late fall through summer, analyze test results and make system recommendations.
PROGRESS: The proposed concept is for peat to be dried by spreading it on a concrete slab under a greenhouse structure. The peat is black in color; consequently, the material to be dried is the radiation absorber. A concrete slab approximately 10.7m by 24.4m with steel rods and mesh for reinforcement was prepared for the base support. A metal tubular frame greenhouse covered with polyethylene was selected and erected with the frame anchored in concrete. The peat is placed on the slab for drying. Moisture content has been determined for the peat in the bog, from the stockpiled peat at the plant, and after the peat has been processed and packaged for sale. The ventilation system and controls for removing the moisture-laden air are being analyzed. Tests will be performed on drying rates as affected by weather, depth of peat on slab, and ventilation.
SUPPORTED BY: Mississippi State Government.

1.0104
DRYING HIGH MOISTURE SEED AND GRAIN TO ENHANCE QUALITY AND MARKETABILITY
Boyd AH, Welch GB, Beck JM, Dept. of Agronomy, Mississippi State University, *Mississippi State, Mississippi, 39762,* (MIS-6219)
OBJECTIVE: Develop techniques for drying forage crop, soybean and small grain seeds for maximum seed quality and marketability. Applications of solar energy to replace fossil fuels in drying applications. Evaluation of single and multiple screw stirring devices as they affect rate and uniformity of seed drying.
APPROACH: Determine heat tolerance, maximum rate and moisture/temperature relationships for soybeans, bahiagrass and selected cereal seeds. Emphasis on solar energy will be for adaptave research (technical and economic) and utilization of solar heat or maximum replacement of fossil fuel on a practical basis. Evaluation of mechanical stirring devices will be done primarily with cooperating farmers and manufacturers because large masses of material are needed for proper evaluation for drying rate and uniformity.
PROGRESS: Studies with isogenic lines of soybean differing only in the impermeable seed coat characteristic showed that seed mechanically harvested at high moisture and artificially dryed resulted in hard seed percent essentially the same (about 20) as those which had dried naturally in the field and were hand harvested. A model dryer was developed to study high temperature and air flow rates on seed quality. New equipment was developed to study the effect of seed moisture and trash content on grain resistance to air flow. Preliminary data indicate that flow resistance is somewhat greater than previously reported (Shedd 1952) probably due to availability of more precise measuring instruments than was available at the time of the earlier studies.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0105
GRAIN DRYING AND CONDITIONING: REDUCTION OF USE OF PETROLEUM PRODUCTS
Brooker DB, Meador NF, McFate KL, Dept. of Agricultural Engineering, University of Missouri, *Columbia, Missouri, 65201,* (MO-00073)
OBJECTIVE: Modify the procedures used to dry grain so that a minimum of petroleum products are used. Develop methods of using and storing solar energy for grain drying, and utilize Missouri weather data in developing controls and procedures for grain drying that reduce petroleum product use.
APPROACH: Simulation coupled with laboratory tests will be used to carry out the research. Laboratory data will check the validity of the simulations and provide input data for new models. Hourly weather data, available from the Department of Atmospheric Science, will be used in the simulation.
PROGRESS: The use of a salt-hydrate eutectic phase change material as a heat storage medium was studied. An eutectic melting at approximately 41.5 degrees C was used. The eutectic was stored in flat trays that were 56.52 cm by 53.34 cm with a thickness of 2.54 cm. The trays were stacked five deep with a space of 3.175 cm between them. Heat was removed from or transferred to air passing between trays. Entering air temperatures were between 14.4 degrees C and 23.4 degrees C when the eutectic was cooled and solidified, and were between 59.4 degrees C and 77.4 degrees C when the eutectic was heated and melted. Air velocities of 2.29, 1.78, 1.27, and .76 m per sec. were used. Definite soiidifying and thawing temperatures were not evident. When the temperature of the

eutectic was plotted against time of heating or cooling, no portion of the curve indicated that a phase change was taking place at a particular temperature. The heat storage capacity of the eutectic and container varied from 16.8% to 33.0% of theoretical for 15 heating tests. For 14 cooling tests the heat storage capacity varied from 25.0% to 50.5% of theoretical.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0106
ENERGY UTILIZATION AS RELATED TO FARMSTEAD MECHANIZATION, MATERIALS HANDLING, AND RURAL LIVING
McFate KL, Christianson LL, Day CL, Dept. of Agricultural Engineering, University of Missouri, *Columbia, Missouri, 65201,* (MO-00077)
OBJECTIVE: Investigate feasibility, performance, costs, benefits related to optimum use of electricity (independently and/or in combination with other forms of energy, especially solar) as related to improved crop and livestock production facilities, handling and preservation of food products, and the effects of energy reduction and/or conservation in rural Missouri.
APPROACH: Determine optimum drying of grain (soybeans) with minimum energy input via field test. In cooperation with animal scientists, energy factors related to different building-production-facility systems will be determined. A combination solar energy-heat pump system will be installed and evaluated for use as major heat source in a farrowing house to determine design parameters and limitations.
PROGRESS: The inability to replace former staff member L. L. Christianson during the year caused activities to be limited to conduct of two 1979 annual educational conferences, to development of a Feb. 5-6, 1980 annual educational conference, to revision of some key publications and to initiation of energy-oriented, energy-assessment field research projects. Publications revised and readied for publication were: "Insulation and Ventilation for Missouri Homes", Bulletin No. C-924. "Is Your Wiring System Properly Protected?", UMC Guide No. 1409. Also under development is an educational manual (publication) with visuals, entitled "Energy for American Agriculture." About 40% completed, this ten unit plan, for leader/youth groups, will clearly show importance of American agriculture and its critical independence upon energy, relative to both current and to future supplies. Research is focused upon assessing energy use in "earth contact" farrowing house and an "earth contact" residence, as compared with local climatic data and with similar conventionally built structures. Preliminary data are being evaluated for report at the 1980 conference for Missouri Farm Electrification Council members.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0107
ANIMAL CALORIMETRY AND ENVIRONMENTAL REQUIREMENTS FOR ANIMAL HOUSING
Shanklin MD, Meador NF, Day CL, Dept. of Agricultural Engineering, University of Missouri, *Columbia, Missouri, 65201,* (MO-00079)
OBJECTIVE: (1) Calorimetric determination of animal heat loss; (2) determination of changes in environmental parameters needed to cause a unit change in animal heat stress; (3) determination of fluctuations in potential energy reserves in mammalian species with specific reference to nutritional, environmental and pharmacological loads; (4) and determination of environmental effects on beef productivity, health and feed conversion efficiency.
APPROACH: Objectives 1 and 3 will be conducted in Missouri Partitional Calorimeter newly equipped with O(2) and CO(2) monitoring capability. Objective 2 will be studied in the Missouri Climatic Laboratory in chambers recently modified to permit individual environment control for 3 animals while also housing 3 control animals. Objective 4 will be carried out in a new facility to be built on the College South Farms.
PROGRESS: Missouri Partitional Calorimeter: A study of the effect of photo period and light-dark cycles on laying hens was concluded and data are being processed. Metabolic rates were measured on the herd of PSS susceptible pigs. A study was initiated to measure the heat changes in eutectic salts used for solar energy storage. Missouri Climatic Laboratory: A study to determine the ability of high producing Holsteins to recover milk production after a period of heat stress sufficient to cause elevated body temperatures was initiated. The animals, chosen from the UMC Holstein herd, and grouped in multiples of six, will be high-producing (22.7 kg/day or above), in their second to fourth lactation, and will enter the study at the peak of their lactation (60-90 days postpartum). Each animal will be retested at 90-day intervals during her lactation, providing measures of stress compensation at early, middle and late stages of lactation. For the entire herd, daily ambient temperature and humidity, milk production and, during seasonal extremes (at a minimum of four-month intervals), rectal temperature will be measured. Blood samples and body weight will be taken prior to laboratory stress exposure and during climatic extremes (January and August). During the first phase of this study, nutrient level and quality will be held constant. During the second phase, nutrient energy level and protein and fiber content will be varied to quantify the heat stress-nutrition interaction.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0108
DEVELOPING EFFICIENT SYSTEMS FOR ROOTING AND ESTABLISHMENT OF CUTTINGS OF WOODY ORNAMENTAL PLANTS
Starbuck CJ, Dept. of Horticulture, University of Missouri, *Columbia, Missouri, 65201,* (MO-00217)
OBJECTIVE: Determine optimum rooting medium temperatures for initiation and elongation of roots in hardwood cuttings at low air temperature. Determine the minimum duration of each of the above temperatures for rapid root development. Develop energy efficient propagation systems. Compare the effects of several propagation techniques on the water relations and survival of cuttings.
APPROACH: Cuttings will be placed, in November, into rooting beds kept at temperatures from 10 - 30 degrees C. A sample of cuttings will be taken weekly from each bed and examined microscopically to determine the time of root initiation. Determine the optimum temperature regime, cuttings will be shifted at intervals from their original temperature to all other temperatures. A propagation system will be constructed using solar heated water to heat the beds. Xylem water potential and survival of cuttings propagrated in flats, poly tubes, and peat pots with and without antitranspirant sprays will be evaluated after planting.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0109
DRYING BEHAVIOR AND UTILIZATION OF MISSOURI WOODS AND RESIDUES
Cutter BE, McGinnes EA, School of Forestry Fisheries & Wildlife, University of Missouri, *Columbia, Missouri, 65201,* (MO-00181)
OBJECTIVE: Monitor drying behavior of native species, primarily black walnut, determine reaction of defects to drying stresses induced during conventional and solar kiln-drying. Determine volume and composition of wood waste piles, both active and abandoned, in Missouri available for energy generation. Measure thermal shrinkage patterns in wood during pyrolysis. Determine the cause of color variation in black walnut heartwood.
APPROACH: Comparisons of walnut gunstock blanks dried conventionally and dried using solar energy will be conducted to determine differences in defect formation. Field surveys will be made to sample wood waste piles at abandoned sawmills to determine suitability of the material for energy generation. Charred wood will be examined using SEM and small-angle X-ray scattering to measure shrinkage and micropore development. Black walnut logs that have been sliced into veneer will be reconstructed with the aid of the computer to determine discoloration and defect patterns within the logs.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0110
EQUIPMENT AND CONSTRUCTION MATERIALS TO MEET ENVIRONMENTAL DESIGN CRITERIA FOR LIVESTOCK FACILITIES
Deshazer JA, Bodman GR, Schulte DD, Dept. of Agricultural Engineering, University of Nebraska, *Lincoln, Nebraska, 68508,* (NEB-11-043)
OBJECTIVE: Test especially designed and constructed buildings and collect mass flow data for heat and moisture. Design buildings for better energy use in animal production. Use simulation models for optimizing beef, swine and dairy production facilities.
APPROACH: Multi-cooperative agreements for mutual benefit of industrial suppliers of buildings, building materials and equipment; farm producers; and University and USDA research personnel will be developed to study and evaluate innovative structural design and equipment. Buildings constructed will be evaluated for the economy of design related to benefits derived from environmental control. Simulation models are to be extended to relate use of solar energy, recovery of latent heat of vaporization, and similar innovations to the production economics.
PROGRESS: A combined passive/active solar collector system was evaluated on a commercial swine growing/finishing farm at Wahoo, Nebraska, latitude of 41 degrees N. The initial passive collectors on the south of the 39 x 9m building were 2.4 x 2.1m. The passive collector panels were revised so that the lower half of the panel could be raised independently of the upper half. This allowed a decrease in man hours required for cleaning the panels, decreased solar heat gain in the early fall and made the panels easier to handling. The active collectors were reconstructed to improve collection and distribution of solar energy. The use of the storage and distribution system to cool the sleeping floor appears advantageous. One summer's data showed an improvement in the growout period by two weeks. The use of the solar system for cooling extends the usefulness of the system and, therefore, decreases the time for payback of the solar system. Investigation concerning the use of infrared heating as an environmental management tool for pig nurseries is being initiated.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0111
USE OF SOLAR ENERGY IN A MODIFIED OPEN-FRONT SWINE FINISHING UNIT
Deshazer JA, Winter DW, Dept. of Agricultural Engineering, University of Nebraska, *Lincoln, Nebraska, 68508,* (7099-20400-010A(4))
OBJECTIVE: Determine the feasibility of using solar energy for substitution of fossil fuel in heating swine finishing shelters, to develop solar collectors which will perform the dual function of collecting solar energy for heating ventilation air and reclaiming heat from exhaust ventilation air.
APPROACH: A swine production house will be equipped with specially designed solar collectors which will heat ventilation air with solar energy and reclaim latent and sensible heat from exhaust ventilation air. Comparison will be made between the experimental unit and a conventional production unit.
PROGRESS: A combined passive/active solar collector system was evaluated on a commercial swine growing/finishing farm at Wahoo, Nebraska, latitude of 41 degrees N. The initial passive collectors on the south of the 39 x 9 m building were 2.4 x 2.1 m. The passive collector panels were revised so that the lower half of the panel could be raised independently of the upper half. This allowed a decrease in man hours required for cleaning the panels, decreased solar heat gain in the early fall and made the panels easier to handle. The active collectors were reconstructed to improve collection and distribution of solar energy. A comparison of absorber plate materials is underway. Also, different construction and mounting techniques for double layer flexible film glazing materials are being investigated. The use of the storage and distribution system to cool the sleeping floor appears advantageous. Data from operation during one summer showed an improvement in the growout period by two weeks. The use of the solar system components for cooling extend the usefulness of the system and therefore decreases the time for payback of the solar system. Investigation concerning the use of infrared heating as an environmental management tool for pig nurseries

is being initiated.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0112
DEVELOPMENT AND OPERATION OF IRRIGATION SYSTEMS
Fischbach PE, Eisenhauer DE, Martin AR, Dept. of Agricultural Engineering, University of Nebraska, *Lincoln, Nebraska, 68508,* (NEB 11-030)
OBJECTIVE: Objective is to develop equipment and procedures for more efficient design and operation of irrigation systems. Improve irrigation scheduling procedures for limited water use. Develop irrigation design and operation procedures for solar energy. Develop irrigation system management procedures to save energy, water and nitrogen. Develop procedures for applying chemicals through irrigation system.
APPROACH: Field studies to evaluate various irrigation scheduling procedures on field size plots - plots replicated. Design and operation of an irrigation system using solar energy. One system replicate by years. Field size plots will be used to study how to apply limited amounts of water at each irrigation. Field size plots studying the application of herbicides through the irrigation water on corn and soybeans.
PROGRESS: A 25 kW Solar photovoltaic power system was installed in 1977. An 80 acre corn field was irrigated using a 13 kW electric motor in 1978 from a reservoir. The same field was irrigated with an 18 kW electric motor in 1979. Two 6000 grain bins with 3.5 kW motors were used to dry the grain from the 80 acre field. In 1979 a 3 kW nitrogen generator was added to utilize the power from the solar system. Herbicides were applied through center pivot sprinkler compared to conventional spray. Lasso-Sincor and Prowl Sencor were compared and at recommended rates immediately following planting of soybeans. Both treatments controlled weeds extremely well. (The principal weeds were green foxtail and pig weed.) The conventional sprayed plots were irrigated the same day when the herbicides were applied through center pivot. The conventional sprayed plots with no irrigation following the ground spraying (not incorporated) was infested with so many weeds that the soybeans were not harvested.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0113
SOLAR ENERGY FOR DRYING CORN IN U.S. PRODUCING AREAS
Thompson TL, Hartsock JG, Dept. of Agricultural Engineering, University of Nebraska, *Lincoln, Nebraska, 68508,* (3090-15705-022A)
OBJECTIVE: Determine through computer simulation, the relative effectiveness of solar energy for in-storage drying of corn in the principal U.S. corn producing areas.
APPROACH: To pilot test the "drying scheduling" model with a limited number of actual drying tests during the fall of 1979. To modify and generally improve the drying scheduling model, incorporating the results and experiences obtained during the fall 1979 pilot testing and ideas and feedback from users to improve the model, the results and the interaction with the users. To utilize the drying scheduling model in Technology Transfer sessions with grain dryer manufacturers, county agents, producers and others interested in low temperature grain drying.
PROGRESS: Simulation studies of low-temperature drying, with both natural air and solar supplementation, were continued. Weather data from 16 locations across the USA were used with 3 fall harvest dates and 4 initial grain moisture contents to establish minimum air-flow rates for successful drying with less than 1/2 dry matter loss. Simulations were also run for drying systems with supplemental heat for locations in 6 states using 10 years' weather data, 3 harvest dates, 4 moisture contents and 4 management strategies. A computer program, "DRYCOST", was developed which facilitates economic analysis of different drying situations by calculating various combinations of cost factor alternatives.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0114
CONSERVATION OF ENERGY AND NUTRIENTS IN LIVESTOCK RESIDUES IN HANDLING AND STORAGE
Gilbertson CB, Hill RM, Doran JD, U.S. Dept. of Agriculture, Agricultural Research, *Lincoln, Nebraska, 68503,* (3416-20400-002)
OBJECTIVE: Determine energy requirements for reducing and controlling water content of beef cattle and swine manure; nitrogen losses with water reduction and storage of manure, and the effect of manure depths on rate of water loss and nitrogen transformation; and study functioning of handling and storage in a prototype swine facility.
APPROACH: Predetermined depths of diluted manure are loaded into beakers on 48-hour intervals and dried to equilibrium moisture content in insulated vaults with selected energy inputs. Daily beaker weights record water loss. Weekly analyses determine nitrogen transformation. Continuous monitoring of temperatures (ambient, manure and plenum), relative humidity, and energy used, will provide data to determine feasibility of application of solar conventional energy sources.
PROGRESS: Manure was stored at initial TS contents of 2, 12, and 30% in containers (with and without caps) within insulated vaults for a period of 19 months. Manure-nitrogen within uncapped and capped containers changed from an initial 4.2% to 2.7% of the dry matter for manure stored at 2 and 12% TS content while the N content of manure stored at 30% TS content was 3.6% d.b. Individual diets were fed to rats contained in metabolism crates. The experiment was designed as a 3 x 3 matrix replicated 3 times varying dietary calcium and phosphorous above, at, and below recommended minimums. Preliminary results indicate that the fate of dietary nutrients is predictable when environmental conditions are held constant. Construction of a hydraulic settling system for a 450 sow swine farrow to finish unit was completed. Fifty-eight percent (by weight) and 65% (by volume) of the solids voided by the animals were removed in the hydraulic settling tank. Flushed manure volume ranged from 230 to 380 m (3) daily. The total solids content of the settled solids ranged from 17 to 19.5%. N content of the inflow, discharge, and settled solids were 2.3 to 2.9%, 3.8 to 5%, and 5 to 6.7%, respectively.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0115
ENGINEERING GREENHOUSE SYSTEMS AND ENVIRONMENTS
Mears DR, Roberts WJ, Janes H, Dept. of Agricultural & Biological Engineering, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJ03130)
OBJECTIVE: Improve the engineering and horticultural aspects of greenhouse production systems adaptable to year-round production under New Jersey growing conditions.
APPROACH: Improved movable insulation systems will be developed and evaluated; alternative heating systems based on solar energy and industrial waste heat will be developed and evaluated; improvements in environmental control systems enabling optimization of energy conserving methods will be undertaken; mechanization of greenhouse cultural operations based on warm floor heating systems will be studied; and cultural practices will be developed to maximize the benefits of new heating and energy conservation systems.
PROGRESS: Operation of the research facilities utilizing solar energy to heat greenhouses has provided experience and data which can be used to design and evaluate proposed commercial greenhouse heating systems. Operation of the half-hectare commercial facility at Kube Pak has provided excellent information and useful experience on the operation of the solar system in full-scale units. Based upon the information obtained, guidelines have been developed for the sizing of the components for commercial systems. Performance of the research and demonstration facilities indicates that the entire system including solar and energy conservation features saves about one sixth of the total cost of the system in one year at current (Fall 1979) fuel prices. A floor heating system utilizing plastic pipes under a porous concrete floor has been developed. Warm water circulating through the pipes has been shown effective in warming the soil of plants grown on the floor. Experience to data indicates that increasing the root zone temperature for many crops enables the air temperature to be significantly reduced with no adverse effect on the plants. The operation of research greenhouse at the PSE and G Mercer Generating Station has shown that warm water from the condensers can be utilized to heat greenhouses with the Rutgers warm flooded floor providing the basic heat transfer unit. Based upon the information obtained, guidelines and criteria for a commercial prototype are being developed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0116
IMPACT OF INCREASED ENERGY COSTS ON THE NEW JERSEY GREENHOUSE TOMATO INDUSTRY
Dhillon PS, Rossi D, Dept. of Agricultural Economics & Marketing, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJ02130)
OBJECTIVE: Analyze the effects of increased fuel prices on the New Jersey greenhouse tomato industry; determine the cost of construction and operation of a solar-heated greenhouse, along with the resultant savings in fuel expenditures and production costs; estimate the level of fuel prices at which solar energy would become competitive with fossil fuel.
APPROACH: The impact of increased fuel prices on the industry will be determined by analyzing the trends in production and number of greenhouse operations in the state. Profitability of using solar heat will be determined by budgeting costs and revenues for a model operation.
PROGRESS: A survey of greenhouse tomato growers in New Jersey was conducted in 1979. According to this survey there were only 19 growers left in the industry representing a decline of 44 percent from 1974. The rapid decline in the number of growers is attributed to the soaring fuel costs. Two benchmark model greenhouse operations have been set up; one heated by oil and the other heated by solar energy. Based on the survey data and a solar greenhouse at Rutgers research farm, construction costs of the model operations have been estimated. Costs of raising an early spring crop of tomatoes in the two houses are being analyzed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0117
HEATING GREENHOUSES WITH SOLAR ENERGY
Mears DR, Butler JL, Dept. of Biological & Agriculture Engineering, Rutgers University, *New Brunswick, New Jersey, 08903,* (7006-20690-09A(1))
OBJECTIVE: Evaluate and refine research prototypes of solar heating greenhouse systems using solar heated water and investigate methods for reducing greenhouse energy use, and low-energy methods of cooling greenhouses.
APPROACH: Continue evaluation of a 13'x28' solar-heated water collector module used to heat a 17'x24' greenhouse. Design, test, and evaluate three 13'x96' solar-heated water collectors each utilizing different framing materials, wood, steel, and aluminum. Use these collector modules to heat water to be stored in three types of floor storage systems, 9"-deep gravel floor with no concrete cap, 9"-deep gravel with porous concrete cap, and 12"-deep gravel floor with walkways only having a porous concrete cap. Modify a 26'x30' greenhouse to test cooling by using movable plastic-film curtains and water films to extract surplus heat from a greenhouse attic and store it in the floor systems.
PROGRESS: Construction of two new greenhouse floor heating systems is underway. A test greenhouse is being fitted with a gravel floor storage system and will be used primarily to test the concept of collecting solar energy within the greenhouse. In this unit, closed cell plastic foam insulation is being laid under the vinyl liner so floor storage to deep soil heat losses can be compared to adjoining units which are essentially uninsulated in the bottom. A small test greenhouse at the horticultural research farm is being fitted out with the gravel/water storage under a porous concrete cap. The primary use of this facility will be the testing of plant response to the warm floor system. A preliminary analysis of the use of a movable

nighttime insulation curtain as a partial shade system to reduce ventilation energy requirements was completed. Based upon this experience, modifications to the system will be developed for further testing. Another test greenhouse is being built to analyze the use of movable nighttime curtains as a partial shade system. Another movable curtain system over which water can run will be used to collect solar heat.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0118
GROWTH AND PHYSIOLOGY OF PLANTS GROWN UNDER CONDITIONS OF HIGH ROOT TEMPERATURES
Janes HW, Dept. of Horticulture & Forestry, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJ12144)
OBJECTIVE: Observe changes in plant productivity due to warm root zones. Determine optimum air and root temperatures for growth in tomatoes. Determine whether changes in productivity due to alteration of photosynthesis respiration, or water and ion relationships.
APPROACH: Grow plants under various root and shoot temperatures in controlled chambers and measure fresh and dry weights as well as leaf areas. Grow plants in solar heated greenhouse under the conditions determined in the controlled chambers. Determine which physiological processes are affected by changing root temperatures.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0119
DEVELOPMENT OF A CLIMATOLOGY OF SOLAR RADIATION INCIDENT OF SLOPING SURFACES IN THE MID-ATLANTIC STATES
Reiss NM, Dept. of Meteorology & Physical Oceanography, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJ00282)
OBJECTIVE: Develop a climatology of solar radiation incident on sloping surfaces that can be used in the design of solar collectors for the mid-Atlantic region of the United States. Attempt to improve existing techniques for parameterizing the diffuse component of solar radiation.
APPROACH: Simultaneous measurements of the direct and diffuse components of solar radiation made over a limited period of time at Maplewood, NJ will be used to test the applicability of several existing techniques for estimating these quantities. Modification in the estimation techniques will be made as suggested by the results of these tests. Tables that give estimates of solar radiation incident on surfaces of various slopes will be produced.
SUPPORTED BY: New Jersey State Government.

1.0120
A DEMONSTRATION SALT GRADIENT SOLAR POND
Unknown, Graduate School, University of New Mexico, *Albuquerque, New Mexico, 87106,* (EG-77-S-04-3977)
OBJECTIVE: Our research is centered on a full-scale salt-gradient solar pond which has been in operation at UNM since 10/75. Our object is to obtain a thorough understanding of the physical behavior of the pond, and the development of a mathematical model adjusted to agree with extensive data taken on the actual pond. Although current research is primarily geared to space heating, industrial process heating as well as crop drying, water desalination, cooling and electricity production are possible applications. In August, 1977, the large storage layer of our pond reached a temperature of 93 degrees C (199 degrees F), which is a record high for sodium chloride ponds with storage. Heat, in the amount required by a 185 square m (2000 square feet) house in Albuquerque, has been successfully extracted from the 175 square m pond on a daily basis since November 4,1977.
SUPPORTED BY: U.S. Dept. of Energy.

1.0121
RAMAH NAVAJO VOCATIONAL TRAINING PROJECT
Vicenti D, Office of Federal Projects, Ramah Navajo School Board Inc., *Ramah, New Mexico, 87321,* (OEG-00-78-C0220)
OBJECTIVE: This project will design, implement, and evaluate a three-year vocational education program for 500 unemployed and underemployed members of the Ramah Navajo reservation, focusing on office occupations, basic and advanced construction trade skills, vocational agriculture, and English-as-a-Second Language. The project will be carried out by the Navajo Ramah school board, which doubles as the major employer of program graduates. Procedures will include providing hands-on training in typewriting, shorthand, telephone use, business writing, carpentry, masonry, blueprint reading, mathematics, plumbing, electricity, sheep dipping, combiotics, birthing, crop cultivation, and solar greenhouses, all in combination with English language training. Curriculum developed by the Mid-America Vocational Curriculum Consortium will be used in both the office trades and constructions skills programs. By providing career awareness, vocational training, and facility in the use of English, the project will create job opportunities for persons wishing to remain on the reservation and will impart skills so that those who wish to leave the reservation will be able to do so.
SUPPORTED BY: U.S. Dept. of Health, Education & Welfare, Office of Education.

1.0122
SOLAR ENERGY CURRICULUM DEVELOPMENT: 7-12 SCIENCE, HOME ECONOMICS, INDUSTRIAL ARTS, HUMANITIES, SOCIAL STUDIES
Boehm TA, State Bureau of Science Education, *Albany, New York, 12234,* (320-6140A)
OBJECTIVE: The Solar Energy Curriculum Development Project will produce solar energy curriculum in grades 7 through 12 science, home economics, industrial arts, humanities, and social studies.
APPROACH: Classroom teachers in each subject area will work with the project staff to develop and field-test draft activities in their own classrooms. A national field-testing of these draft materials will follow and revised documents will be produced. Final products will include a revised solar energy text, reader, teacher's guide, and booklets of science activities in junior high science, chemistry and physics, biology, earth science, and general solar topics, as well as revised booklets of activities for home economics and industrial arts and draft booklets for humanities and social studies. The national field-testing of the science materials is completed, and a revision of the text, reader, and science activities is underway. Draft curricula in industrial arts and home economics are now being edited, and should be available for national field-testing in January 1981.
SUPPORTED BY: U.S. Dept. of Energy.

1.0123
DESIGN OF A PASSIVE SOLAR GREENHOUSE
Esposito JA, Four Seasons Solar Products Corp., *Farmingdale, New York, 11735*
OBJECTIVE: The objective of this cooperative agreement is to develop a glazing system which will be an efficient passive solar collector, will enclose space as a sunspace or a greenhouse does and be compromised in both quality and aesthetic appeal. In addition, the system must be flexible for a wide variety of applications in both existing and new construction and must be modular, to realize the cost benefits of both mass production and mass marketing. This product will be an intergrated system incorporating the following major tasks: (1) develop a sound structure which will allow double and triple glazing; (2) develop an acceptable night insulation system; and (3) develop an automatic ventillation and solar shading system to control temperature during the summer.
SUPPORTED BY: U.S. Dept. of Energy.

1.0124
HEATING OF GREENHOUSES AND RURAL RESIDENCES WITH SOLAR ENERGY
Albright LD, Butler JL, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (7705-20690-018A(1))
OBJECTIVE: Develop and evaluate an active-passive hybrid solar heating system utilizing low-cost solar heat collection and retrieval and the concept of variable mass for solar heating of greenhouses.
APPROACH: Test and demonstrate a new low-cost concept for utilizing solar energy to heat greenhouses; match solar heating components into the "Q-Sol" system to produce compatible night and day greenhouse conditions, with the "night" greenhouse effectively shrunk to contain only the plants and a heat source by using a variable thermal mass and a hybrid active/static means of solar energy retrieval. Determine night temperature requirements of a variety of plants to find those suited to the characteristics of passive solar heating systems. Formulate a method to interrelate capital costs, market factors, and plant factors as an analysis tool to predict cost effectiveness of patented greenhouse solar heating systems.
PROGRESS: An analysis of one winter's operation of a Brace style greenhouse with insulated north and end walls and a double polyethylene cover was completed. Operational results are compared with a conventional double polyethylene greenhouse and a glass covered greenhouse. The analysis also included operation of the Brace style greenhouse with and without a highly insulated night cover (HINC) consisting of five layers of an aluminized fabric. It was determined that the heating load (HLF) of the Brace greenhouse was only about 17% lower than for the double polyethylene (DP) greenhouse. The HLF for the glasshouse (single glazing) was 67% greater than for the DP greenhouse. With the HINC installed in the Brace greenhouse, nighttime HLF was greatly reduced and at least 90% of heating needs was supplied by the sun with only passive retrieval at night.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0125
SOLAR HEATING AND COOLING OF GREENHOUSES AND RURAL RESIDENCES
Albright LD, Langhans RW, White GB, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123326)
OBJECTIVE: This study is proposed to provide sound technical information to evaluate the overall merits of utilizing solar energy for heating and cooling of greenhouses and residences. The effort will be directed toward the application of present collector and storage technologies to greenhouses and residence systems. The general objective will be to analyze, design, and test the combination of solar collection devices and storage systems to utilize solar energy as effectively as possible to provide the greatest possible portion of the energy required.
APPROACH: An interdisciplinary team of engineers, architects, and economists will carry out detailed engineering analyses, design of building forms, and economic analyses to satisfy the objectives of the project. An existing solar energy house will be instrumented to measure the effectiveness of solar energy use. Mathematical models of the greenhouse heat balance will be developed and used to simulate the application of solar energy to heating of greenhouses.
PROGRESS: The multilayer, highly insulated greenhouse has been tested further and shown to save at least 80% of night heating needs. A new deployment system for the cover has been patented by Cornell University and a local firm has been formed to market it on license from Cornell. Sliding night temperature has been tested further. Lettuce, roses and chrysanthemums have all shown an ability to integrate a variable night temperature and treat it as a constant temperature. An economic analysis model for greenhouse energy conservation has been developed. It is now available for use in an extension model. A computer model has been developed to predict optimum opening and closing times of night curtains. The results show that control by light level outside, rather than a timeclock, is definitely preferred.
SUPPORTED BY: New York State Government.

1.0126
SOLAR DOMESTIC WATER HEATING IN RURAL/MIGRANT HOUSING
Stipanuk DM, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850*, (NYC-123341)
OBJECTIVE: Reduction of the cost of water heating for rural dwellings by the substitution of a renewable form of energy for currently used electric or LP fuels would aid the economic viability of rural people. The publication of actual experience with solar systems in NYS would greatly aid the people of NYS as they assess the viability of solar water heating for their homes. The training of installers for solar water heating systems will improve system reliability and reduce costs.
APPROACH: Seven to eight solar domestic water heating systems will be installed in migrant worker dwellings near Sodus, NY. Installations will be made by CETA workers following completion of a training course. Performance of these solar systems will be monitored and reported on a regular basis. Comparisons will be made to conventional (electric) water heating systems in similar dwellings.
PROGRESS: Installation of eight (8) solar water heating systems in low-income dwellings near Wolcott, New York completed. Performance monitoring of systems began with help from Rochester Gas and Electric staff. Performance results to be published in forthcoming Extension bulletin on solar system performance in New York State.
SUPPORTED BY: New York State Government.

1.0127
STUDIES OF PHOTOSYNTHETIC ENERGY CONVERSION
Clayton RK, Division of Biological Sciences, Cornell University, *Ithaca, New York, 14850*, (EY-76-S-02-3162)
OBJECTIVE: Having pioneered the isolation and characterization of the photochemical reaction centers that initiate the conversion of light to chemical energy in photosynthetic organisms, we have gained a detailed knowledge of the earliest physical and photochemical processes of photosynthesis by studying the behavior of these reaction centers. Based on our findings, workers in other laboratories have begun to succeed in constructing artificial reaction centers - molecular complexes that duplicate the events of natural photosynthesis. These advances may help to develop methods of solar energy conversion based on photosynthesis. We have begun to elucidate the detailed structures of the natural reaction centers, through measurements with polarized light. We are also extending our knowledge of secondary electron transfer processes that follow the primary photochemistry and lead to the formation of ATP. These studies have been made principally with photosynthetic bacteria.
SUPPORTED BY: U.S. Dept. of Energy.

1.0128
RESEARCH IN THE USE OF SOLAR ENERGY IN AN ALTERNATIVE METHOD FOR NITRATE PRODUCTION
Bull SR, Dept. of Chemistry, Rensselaer Polytechnic Inst., *Troy, New York, 12181*
OBJECTIVE: This is continuing research into the hypothesis that air can be used as a source of nitrates for fertilizer production. The idea is to use metal oxides in contact with the air so that the oxide can react with the nitrogen oxides as they are formed, continuously producing nitrates. Solar energy is proposed as the heat source.
APPROACH: The first six months of this study dealt with identifying and verifying catalysts, availability of oxides, determining temperature-pressure-composition equilibrium data for various oxides, and performing limited experimental studies. This second part of the study will concentrate on three additional tasks: (1) experimentally verify nitrate formation at high pressures and temperatures with an appropriate oxide in a gas flow system; (2) determine a detailed flow diagram for the process; and (3) perform a preliminary estimate of the cost of the system. Later research will concentrate on construction, testing and evaluation of a bench-scale prototype apparatus for nitrate production.
SUPPORTED BY: U.S. Dept. of Energy.

1.0129
SOLAR ENERGY APPLICATION AND ENERGY CONSERVATION FOR LOW INCOME RURAL FAMILIES
Streat WA, Dept. of Architectural Engineering, North Carolina Agricultural & Technical State University, *Greensboro, North Carolina, 27411*, (NC.X-PR-0001)
OBJECTIVE: Develop energy conserving designs of economically feasible systems to meet energy needs of housing for low income rural families.
APPROACH: Preliminary work will include making a survey of housing and energy needs of rural low income people of North Carolina and making a feasibility study of utilizing non-conventional energy sources in existing rural houses using solar energy. Price and performance data will be gathered on currently available solar hardware and computer codes will be written to perform systematic economic optimization studies. Cost effect system designs (one hydronic and one air) will be developed and made available to rural families.
PROGRESS: The final report for this project is being completed. Two type solar collectors have been designed and constructed - one air and one liquid. Some tests have been made to determine efficiency. The report will provide data to be used by rural families in an effort to conserve energy. Information to rural families will be circulated by the A and T Agricultural Extension Service.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0130
A BENEFIT-COST APPROACH TO POTENTIAL SOLAR ENERGY UTILIZATION IN RURAL RESIDENCE OF WESTERN NORTH CAROLINA
Chen DY, Dept. of Economics & Business, North Carolina Agricultural & Technical State University, *Greensboro, North Carolina, 27411*, (NC.X-013-5-79-531-5)
OBJECTIVE: Develop a conceptual framework for the quantification of the costs and benefits on potential solar energy utilization for space and water heating in rural western North Carolina residences; gather and analyze information and the responses in terms of the awareness and acceptances of potential solar energy utilization from selected rural residents; establish a set of tentative criteria on the potentiality of solar energy utilization in rural housing and provide feed-back to rural residents for actual application, to governmental agencies for policy considerations, and researchers for further studies.
APPROACH: This research will be conducted in a benefit-cost economic analytical framework using primary and published data including field survey in selected counties in western North Carolina. Selected models of solar space heating and solar water heating based on the existing technology will be used as the foundation in seeking responses and establishing criteria for potential propagation.
PROGRESS: Preliminary findings on the housing characteristics in the study area indicated that 11.6% of all year-round housing units in the state of North Carolina were found in the 18-county area or approximately 187,000units. Structure-wise, the majority of the houses were found in one-unit housing or 80%. Mobile homes accounted for 7% being the next largest group. One-third of all houses were built after 1960. This implies that two-thirds of the houses to be surveyed may be more than 20-years-old which may affect the possibility for considering alternative energy sources for space and water heating. A research team is about to be assembled.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0131
HOUSING FOR LOW-AND MODERATE-INCOME FAMILIES
Baird N, Walden M, Dept. of Home Economics, North Carolina Agricultural & Technical State University, *Greensboro, North Carolina, 27411*, (NC11141)
OBJECTIVE: Provide designs and assistance for constructing prototype housing systems; determine societal constraints for housing alternatives; analyze housing delivery systems and develop methods of disseminating housing research information.
APPROACH: Will be concerned with the analysis of solar attic houses; and will be analyzed by compiling known housing alternatives and investigated for current and future use potentials. Emphasis will be directed to the financing mechanisms; identifying and examining information networks by testing alternative ways of disseminating information.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0132
SOLAR ENERGY UTILIZATION IN TOBACCO BULK CURING/GREENHOUSE SYSTEM
Huang BK, Butler JL, Dept. of Biological & Agricultural Engineering, North Carolina State University, *Raleigh, North Carolina, 27600*, (7095-20190-007-A(3))
OBJECTIVE: Provide for practical aspects of immediate and effective utilization of solar energy for tobacco curing and greenhouse crop production.
APPROACH: Based on previous research for this system, computer aided analyses, modeling and simulation will be used to evaluate and optimize the collector design, energy storage and automation of air flow during curing. These design changes will be made on the existing bulk curing/greenhouse structure. Tests will be conducted on tobacco curing and data necessary for performance and cost utilization and for further analysis and simulation will be collected using a microprocessor based data acquisition system. Tobacco seedling and other plant growth research will be conducted in a bulk curing/greenhouse structure. Continuous growth data will be taken to determine the optimum environment for multi-layer growth of tobacco seedlings. Other greenhouse crops will be grown and studied for maximum economical utilization of the structure as a greenhouse.
PROGRESS: The multi-purpose solar energy greenhouse/solar curing system was modified by adding an M-series based microcompurter to control solar energy collection, utilization and storage. The system was used to control air flow in curing tobacco using three microcomputer software programs. The first program was a data acquisition program which measured temperatures and provided this data to the other two programs (for curing) for processing and subsequent control. Using this system, the greenhouse/solar curing system achieved a 49% energy saving compared to the conventional curing barn. A rotary dryer was constructed and installed in the facility in the place of the bulk curing barn. This facility was used to cure four lots of peanuts. Problems of drum rotation were encountered. These were solved and satisfactory drying resulted in the later tests.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0133
ENERGY REDUCTION FOR ON-FARM PROCESSING OF AGRICULTURAL PRODUCTS
Johnson WH, Young JH, Dept. of Biological & Agricultural Engineering, North Carolina State University, *Raleigh, North Carolina, 27600*, (NC01147)
OBJECTIVE: Determine energy consumption of various harvesting, processing and storage systems. Reduce or substitute for fossil fuel required in existing systems for processing agricultural crops. Develop new energy efficient systems for processing agricultural products.
APPROACH: Specific energy usage for curing of tobacco and peanuts will be determined from controlled experiments. Current methods will be analyzed to determine feasibility of changes to achieve greater energy efficiency. A multi-chamber solar tobacco curing system with heat recovery will be evaluated and simulation models developed to optimize system performance. Automatic temperature-humidity systems will be developed to improve drying efficiency in peanut curing and tested under field conditions. Modification of drying properties of tobacco by shredding or heat treatment will be studied.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research office.

1.0134
ENGINEERING FOR FLORICULTURAL AND ORNAMENTAL CROP PRODUCTION
Willits DH, Dept. of Biological & Agricultural Engineering, North Carolina State University, *Raleigh, North Carolina, 27600*, (NC03549)
OBJECTIVE: Reduce energy costs and improve environmental control in greenhouses; reduce labor/production costs of nursery and greenhouse operations.
APPROACH: Attempts to reduce energy costs will be made by incorporating rock bed storage systems into greenhouses. Reduction of nighttime heat losses and development of alternate energy sources will be investigated. Mathematical models will be developed to facilitate improved environmental control. Attempts to reduce labor/production costs in nursery and greenhouse operations will be made by using a systems approach. Totally integrated production models will be developed and used to evaluate production alternatives and optimize resource allocations.
PROGRESS: A full-size rock bed has been in operation for 1 1/2 years. During winter 78-79 tomatoes were grown and the fuel savings amounted to 23.3%. Lettuce was grown during the fall of 1979 and the temperatures were reduced accordingly (12 degrees C night, 17 degrees C day, 22 degrees C vent). Fuel savings for October-December 79 were 37.2%, up from 19.6% for the same period in 1978. Laboratory studies have been conducted to determine heat transfer and pressure drop characteristics of crushed rock at low temperatures (10-30 degrees C). Correlations have been proposed and will be published shortly. Additional studies are under way to model the thermal behavior of greenhouse collection/storage systems and to predict their performance under widely varying conditions. Advancements under the systems analysis part of the project have centered around the development of a linear program which optimizes the production of potted crysanthemums on a yearly basis. The model considers each weekly planting as a separate crop with its own cost, labor and space coefficients and constraints. Outputs include crop mix and weekly labor and space demand. Labor demand is broken into categories of labor, i.e., management, high-skilled and low-skilled. A schedule of critical operations to be performed is also included. The model has been checked out using real data but as yet the results are trivial since it considers only crysanthemums.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0135
LOW-GRADE THERMAL ENERGY STORAGE SYSTEMS FOR GREENHOUSES
Willits DH, Butler JL, Dept. of Biological & Agricultural Engineering, North Carolina State University, *Raleigh, North Carolina, 27600*, (7010-20690-023A(1))
OBJECTIVE: Develop and test low-temperature rock-bed storage systems that can be added to existing solar-heated greenhouses and determine specific engineering to facilitate the design and use of such systems in an economic manner.
APPROACH: Construct a laboratory-size rock storage bed and determine the fuctional relationship among pressure drop, air flow, rock size and shape, bed porosity, and bed height. Construct a full-scale rock bed based on these relationships next to a 6 m x 12 m fiberglass quonset greenhouse for storage of excess collected greenhouse energy and compare the energy economy and plant growth in this greenhouse with a similar greenhouse without rock storage.
PROGRESS: Construction was completed on a full size (13.4 m multiplied by 3 m multiplied by x 1.8 m) rock thermal storage for use in greenhouse solar heating. The greenhouse collection/storage system is controlled by a microprocessor-based control system recently developed for this purpose. A separate microprocessor-based data acquisition system monitors temperature at various points in planting beds, as well as in the greenhouses, to determine the operational characteristics of the system. Tests will begin as soon as the control dampers are installed. The target date for this is 10 October and work is proceeding on schedule. A computer program will be developed to model the system and extrapolate performance predictions outside the range of collected data.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0136
GREENHOUSE VEGETABLE PRODUCTION
Miller CH, Jenkins SF, Kennedy GG, Dept. of Horticultural Science, North Carolina State University, *Raleigh, North Carolina, 27600*, (NC03558)
OBJECTIVE: Develop procedures for efficient production and protection of greenhouse vegetables. Rates, ratios and timing of nutrients will be studied with tomatoes and cucumbers including spatial arrangement, watering and media. Feasibility studies with new cultivars and other crops will be conducted. Insecticides and acaricides; mist evaporative systems, covering materials and structural modifications will be evaluated. With tomato and cucumber as test crops, arthropod pest species will be identified and life histories studied. Severity of pathogens on tomato and other crops will be studied. Control measures involving chemicals, cultural practices will be devised. Heating, cooling, humidity control and mechanization will be researched along with solar energy.
APPROACH: Standard and potential greenhouse crops will be provided specific environments necessary for each discipline with some overall perimeters providing bridges among disciplines (i.e., standard varieties, fertilizer treatments, pesticide treatments, and equipment for environmental modifications). Overall plant responses including yield and reaction to the biological and environmental hazards will be measured, evaluated and published.
PROGRESS: 1978 studies included continuation of the insulated north wall experiment and the comparison between fiberglass and double-poly coverings. An experiment to determine the amount of energy that can be collected by a greenhouse during the day and stored for use at night was added. A rock bed containing 50 tons of crushed granite has been connected to a greenhouse and the operating characteristics will be compared to a control house located immediately adjacent to it. Results have not yet been compiled and analyzed. Various insecticides were evaluated for control fo Trialeurodes vaporariorum, Liriomyza sativae and Keiferia lycopersicella. Only methomyl provided acceptable control of T. vaporariorum and K. lycopersicella, while only diazinon provided acceptable control of L. sativae. Two lb. maneb/100 g. H(2)O at 7 day intervals gave better control of early blight than the same treatment at 14 days. One lb. rates were even less efficient. 'Manapal' was much more resistant to early blight than 'Bonny Best'. A 1978 experiment was initiated to determine the effects of 4 planting media with uniform daily liquid fertilization on production schedules and yield.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0137
DEVELOPMENT OF INEXPENSIVE AQUACULTURE SYSTEMS FOR HOME (SUBSISTENCE-TYPE) CULTURE IN NORTH CAROLINA
Hassler WW, Dept. of Zoology, North Carolina State University, *Raleigh, North Carolina, 27607*, (NC05448)
OBJECTIVE: To develop inexpensive and efficient methods of fish culture for home consumption. To determine best species of fish and algae for home culture. To determine costs involved in home culture system.
APPROACH: Use translucent solar-algae tanks and use solar energy to grow algae which can be utilized by herbivorous fish (tilapia). Determine methods of utilizing solar-algae tanks throughout year: outside with insulation; within greenhouse; outside with cold-tolerant species; outside with solar collectors. Determine production of different species in monoculture, polyculture, and diseasonal use.
SUPPORTED BY: North Carolina State Government.

1.0138
PLANTS IN PASSIVE SOLAR ENERGY SYSTEMS
Zuber RE, Dept. of Horticulture & Forestry, North Dakota State University, *Fargo, North Dakota, 58103*, (ND02222)
OBJECTIVE: Evaluate radiation transmission of deciduous native and ornamental plant species for their potential usefulness with passive solar energy systems. Establish criterion by which plants may be compared and selected for use in passive solar energy systems.
APPROACH: Solar radiation transmitted through deciduous plants will be measured. Both native and ornamental trees, shrubs, lianas, and vines will be studied. Comparison between species will be made to determine which plants are best suited for use in passive solar energy systems.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0139
DESIGN, FABRICATE, TEST AND MARKET A ENERGY EFFICIENT SOLAR GREENHOUSE THROUGH INNOVATIVE ENGINEERING
Colby WL, Solar Central, *Mechanicsburg, Ohio, 43044*,
PROGRESS: The final design drawings, including the various energy saving engineering approaches to be incorporated, have been completed. A project manager for the participant in this agreement has been hired to serve in liaison with the government project manager as well as to coordinate all other activities involved for the greenhouse project. The location of the greenhouse has been surveyed and leveled. The vertical main support posts (special stress factors) have been set into concrete, along with flat metal plates welded to the bottom, for additional stability. The vertical center supports have been obtained, post holes dug, and set into concrete. A ditch around the perimeter of the building has been dug, with the closed-cell styrofoam installed. The lower doors that open and close in a synchronous manner have been perfected, these allow the moveable insulation to fill the required spaces.
SUPPORTED BY: U.S. Dept. of Energy.

1.0140
CONSTRUCT A SOLAR KILN FOR DRYING SAWN LUMBER
Dixon ST, Sherwood Forest Products Inc., *Waverly, Ohio, 45690*
OBJECTIVE: The project proposes to design and construct a commercial demonstration solar kiln for the purpose of drying sawn lumber. The structure will be extensively monitored and evaluated after construction. The solar system will utilize a site built fan driven air collector to dry the lumber. Under average conditions we anticipate drying 4/4 red oak from 70% to 20% moisture content in six weeks.
SUPPORTED BY: U.S. Dept. of Energy.

1.0141
A SOLAR POND FOR WINTER HEATING OF GREENHOUSES AND RURAL RESIDENCES
Short TH, Roller WL, Fynn RP, Dept. of Agricultural Engineering, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691*, (OHO00300-SS)
OBJECTIVE: The completion of research needed to evaluate the economics of the application of solar ponds to greenhouse heating and the production of a Comprehensive Solar Pond Construction and Users Manual such that a solar pond can be built and operated by farmers and growers.
APPROACH: Evaluation of optimum salt content in order to produce a pond with minimal, but adequate, capital investment commensurate with maintaining salt profile stability for the range of temperatures required by the design features. Evaluation of the role played by a heat pump in conjunction with a solar pond for increasing the range of temperature over which the pond will operate. Evaluation of alternative heat exchangers using fresh water as the heat exchange medium. Systematizing results and reducing to handbook format.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0142
SOLAR HEAT FOR GRAIN DRYING IN OHIO
Keener HM, Hartsock JG, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691,* (3090-20598-020-A(1))
OBJECTIVE: Determine the economic and technical feasibility of using solar energy to supplement or replace other fuels in drying grain.
APPROACH: Collect field data on side wall of a machine shed covered with double-layered and air inflated plastic cover. Collect field data on natural and solar assisted drying to test management strategies for grain drying developed during 1976-78 simulation studies. Continue to evaluate the investment cost and operating cost of solar heated batch drying systems, with and without heat storage, for various initial grain moistures and different types of heat storage devices. (This continued evaluation in Ohio is important since electrical energy costs have sky-rocketed, going above 9/cent/kwh during 1978). Develop a bulletin describing 1974-1978 research results on solar crop drying in Ohio outlining management practices and systems which lend themselves to solar energy.
PROGRESS: Simulation studies were continued, together with the gathering of critical input data. Performance of air-inflated plastic collectors was analyzed and recommendations developed for efficient use and prolonging useful life. A logarithmic drying model was validated for design of low-temperature solar-supplemented systems. Optimization studies were also continued with emphasis on batch systems, and a total systems analysis of corn production was developed.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0143
SOLAR HEAT FOR GRAIN DRYING
Keener HM, Roller WL, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691,* (OHO00232-SS)
OBJECTIVE: Determine effectiveness of solar collectors in heating air, effects of solar heated air (low temperature) compared to unheated air on the rate of drying soybeans and shelled corn, effect of weather variations on solar collectors, operational procedures for using bin dryers with solar collectors.
APPROACH: Conduct a field study on integrated solar heat collector grain drying systems under field conditions. Study will use three bins, each 14 ft. dia. x 8 ft. high. Two bins have solar collector units (an inflated plastic cover over a 1000 ft black plastic obsorber) connected for the heated air studies, one using continuous air flow and one moving drying air only during daylight; while one bin will be using unheated air in continuous operation. Simulation of solar drying systems will be made.
PROGRESS: A black painted vertical panel with a double layer of plastic was tested for use as a low temperature solar collector on a farm structure. Collection efficiency was 30% at an air flow of 1.45 meter per minute (flow/collection area). A commercial plastic solar collector, SOLORON, was tested from 1974 to 1977. It's efficiency dropped from 40% to 32% in 18 months (life of collector) of use. A new plastic solar collector from Kuss Corporation, was used during 1978 tests and found to be about 45% efficient. 1974-78 low-temperature and natural air grain drying tests suggest that instantaneous solar energy utilization will economize electrical energy consumption during low-temperature drying, but cost can still exceed that of high temperature drying. Engineering and economic analysis of a high performance solar collector, SUNPAK, coupled with storage, indicated that this system for Fall grain drying would be about 18 times more expensive compared to using electricity (5 cent/kwh) and LP gas (45 cent/gal.). Based on 1975 Wooster, Ohio weather (year of lowest radiation level from May through September for years 1970-77), the simulation indicated that a water storage tank of 545,000liters coupled to 238 sq. m. of SUNPAK would reach about 95 degree C temperature (with no heat loss considerations) and would suffice for drying 254 Kilo tonnes of corn from 25% (w.b.) with 60% heat exchanger efficiency.
SUPPORTED BY: Ohio State Government.

1.0144
MECHANIZATION OF GREENHOUSE CULTURAL AND ENVIRONMENTAL SYSTEMS
Short TH, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691,* (OHO00576)
OBJECTIVE: Establish new technology to reduce labor cost, labor drudgery, and fossil fuel heating requirements for greenhouses.
APPROACH: Labor-aid mechanisms will be developed to reduce drudgery and increase labor efficiency of growing greenhouse crops under present cultural systems. Machinery will be developed for high population cultural systems to achieve high production of tomatoes, lettuce and other greenhouse crops. Mechanical methods of adding nighttime insulation to greenhouse covers will be developed and tested. Mechanical systems for transferring heat to a greenhouse from solar collectors and heat storages such as a solar pond will be studied and developed. Greenhouse energy sources will be integrated into workable, efficient, and economic systems of crop production.
PROGRESS: Major emphasis has been to develop a mechanized polystyrene bead insulation technique to reduce greenhouse night energy requirements by 80-90%. Five inches of beads are pumped between double plastic walls at sundown and removed at sunrise for an insulation R^5 20 (normal R^5 1.4). Beads (3 - 6 mm. dia.) are pumped through blowers with air. This mechanical handling causes no apparent deterioration of the 16 kg/mue3 material. An air/bead ratio of 25:1 results in near optimum pump capacity. The 25:1 ratio is typical during filling but 50:1 usually occurs while evacuating the greenhouse covers. On an experimental 6m x 12m greenhouse, a 0.75 Kw blower rated at 28 CMM (3450 RPM, 25 mm static water pressure (s.p.)) will pump about 1.3 cu. m of beads per minute and fill the house in 12 min. The mixture is pumped at less than 25 mm. s.p. to prevent plastic rupture. Air is continuously evacuated from between the plastic sheets with a similar-sized blower to prevent rupture and control the thickness of fill. Static cling of the beads is controlled by 135 ml of glycerine added to each cubic meter of beads. Other antistatic chemicals are also effective. Moisture between the plastic is a problem during sub-freezing weather. Beads can freeze on the inside surface of the outside cover and cause shading. All air inlets to blowers should be outside the humid greenhouse, and the bead storage should be dried with one of the blowers on dry days. Many refinements are still required before commercial application.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0145
EXPERIMENTAL STUDIES ON A SOLAR POND FOR HEATING AND COOLING GREENHOUSES AND RESIDENCES
Short TH, Butler JL, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691,* (7008-20690-021A(1))
OBJECTIVE: Demonstrate a working solar pond and heat extraction system for heating an adjacent greenhouse and evaluate the economic feasibility and efficiency of a solar pond as an integrated solar collector and heat storage unit for greenhouses and homes.
APPROACH: A salt pond (28x60x12 ft deep) will be monitored for daily temperature and salt concentration gradient. Radiation profiles above and within the pond will be studied under different weather conditions and seasons. The efficiency of a heat extraction system will be measured and the salt pond will be evaluated as a solar energy collection and storage system for providing solar heat for greenhouses or residences. Emphasis will be given to developing design criteria for optimum pond depth, required insulation in sides and bottom, required size of gradient zone, and required maximum salt concentration for stability and maintenance. A computer model will be developed to simulate the solar pond heating system and an energy accounting system will be developed to evaluate the various energy pathways in the experimental system.
PROGRESS: Performance of the modified and better insulated thermal pond was monitored. Daily pond temperature increases since March 27 averaged 0.65 degrees F until on June 20 when pond temperature reached 121 degrees F. A maximum temperature of 133 degrees F was reached by July 21. From then the pond held an equilibrium temperature of about 132 degrees F. Salt concentration was varied in an attempt to improve performance and this change is still being evaluated. Collection efficiency of the pond was about 20%. A new method for heat extraction and distribution was installed in the pond and adjacent greenhouse. The new system circulates warm brine in plastic pipes between the pond and a shell and tube heat exchanger. Results to date indicate the system is working, but not enough data is available for evaluation.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0146
RESEARCH ON SOLAR PONDS FOR HEATING AND COOLING GREENHOUSES AND RURAL RESIDENCES
Short TH, Roller WL, Curry RB, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691,* (OHO00238-SS)
OBJECTIVE: Lower fossil fuel heat requirements for greenhouses and residences by studying a "bubble" covered solar salt pond (sized for a single family 2000 ft residence) as an integrated solar collector, heat storage unit, and heat source for a greenhouse.
APPROACH: A salt concentration gradient will be established to keep the pond non-convective to attain 90 C temperatures. A plastic greenhouse will cover the pond for heat retention and weather protection. Heat will be extracted by a fresh water heat exchanger. The fresh water will either be used directly in the greenhouse or warmed by a heat pump. The heat pump will also be evaluated for moving heat from the greenhouse to the pond. An energy accounting and budgeting system will be developed for correct source, flow and sink for heat at various times.
PROGRESS: An experimental solar pond (8.5 x 18.3 x 3 m deep) is designed to demonstrate the heating of an adjacent greenhouse. A controlled salt concentration gradient in the upper half prevents convection and is a transparent insulator while the bottom is convective. During 1978, the average daily pond temperature increased 0.33 degrees C/day from March 21 (16.8) until July 21 (56 degrees C). The temperature rose 0.8 degrees C/day during 4 clear days. A goal of 80 degrees C may have been reached except that convection in the lower half of the pond eroded the insulating gradient resulting in a 55 degree C equilibrium temperature during the latter part of the summer. Salt was added along the base of the north wall to halt gradient erosion, but the whole stability problem needs further evaluation. A heat extraction system was installed with a shell and tube heat exchanger for transferring heat from the brine to water. When the pond is above 40 degree C, water is circulated through a coil in a greenhouse air handler. When the pond temperature is below 40 degree C, the warmed water is piped to a heat pump. The heating system was operated successfully without disturbing the gradient. Numerous startup problems were associated with regulating water flows to match the capacity of the 7.5 KW heat pump. The results to date indicate the heating system as designed will work, but not enough data were obtained to establish operational efficiencies and design guidelines.
SUPPORTED BY: Ohio State Government.

1.0147
SWINE ENVIRONMENTAL SYSTEMS TO OPTIMIZE FEED AND FUEL UTILIZATION
Stombaugh DP, Roller WL, Ohio Agricultural Research & Development Center, *Columbus, Ohio, 43216,* (OHO00620)
OBJECTIVE: Develop improved environmental modification techniques which reduce energy consumption and develop a simulated model describing nutritional-environmental interactions in swine to evaluate these environmental modification techniques.
APPROACH: This dynamic model will provide rate of gain, body composition, and feed efficiency responses to changes in feed energy intake, diet composition, frequency of feeding and the thermal environment. Model development will utilize data in the literature and data from

laboratory studies in an environmentally controlled calorimeter. The proposed environmental modification techniques will be designed and evaluated theoretically using prototype models and then installed on the farms of commercial operators to evaluate economic and technical feasibility.
PROGRESS: A dynamic simulation model has been developed which describes feed intake; digestion and absorption; the chemical-biological pathways for carbohydrates, fats and proteins; protein and fat synthesis and degradation; whole body energy balance and thermoregulation. Model parameters have been evaluated by comparing model predictions with experimental and theoretical work. The model simulates growth and energetic efficiency in pigs between 5 and 25 weeks of age in more detail than previous models. To validate the model, comparisons will be made with results to be obtained from a recently completed animal calorimeter. This calorimeter houses a group of pigs (up to four) and permits the continuous determination of sensible and latent heat losses, oxygen consumption, and feces and urine collection. Preliminary calorimeter calibrations and trial runs have been completed and experimental trials are being initiated. Initially, the experimental trials will include the evaluation of protein level (12 and 18%, temperature (15 degrees and 30 degrees C) and step changes in temperature on the performance of six- to ten-week-old pigs. A new environmental control system for warm confinement animal housing using subsurface energy extraction and dispersal has also been designed for farrowing and nursery buildings. Additional funding is being sought to test this system and various solar energy systems for swine housing.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0148
DRYING FOOD MATERIALS BY DIRECT APPLICATION OF SOLAR ENERGY
Brusewitz GH, Dept. of Agricultural Engineering, Oklahoma State University, *Stillwater, Oklahoma, 74075,* (OKLO1652)
OBJECTIVE: Demonstrate the use of a directly heated, enclosed solar dryer for drying food materials during processing. The objectives, for the first year are to: design, construct and test laboratory-size, direct-heated, enclosed solar dryers to dry high moisture food materials. Determine the drying characteristics of the material (initially this would be paunch) as a function of time, temperature, operating procedures, and paunch constituents. Investigate the handling aspects of the material in order to determine the need for a mechanical stirring mechanism and/or perforated bottom to insure maximum drying. Determine the conditions, both optimum and limiting, under which the dryer will operate in an environmentally acceptable procedure.
APPROACH: A direct heated, enclosed solar dryer will be designed based on the information in the literature. Beef packing plant paunch, a waste product in the past, will be used as an example of a high-moisture, low-value food processing plant material. The drying rate of this paunch material will be measured to predict the operation of a pilot-size solar dryer in future years. Operating procedure variables expected to have major influence are material depth, frequency of paunch filling and dried material removal, and initial and final moisture content.
PROGRESS: A prototype direct solar dryer to dehydrate cow paunch contents was designed, built and tested. During good insolation, the dryer operated as a modified solar still with the vaporized moisture condensing on the under side of a fiberglass cover. During periods of low insolation, drying was done by a solid desiccant, silica gel. The desiccant was later regenerated by solar heated air from a concentrating collector. Of four tests in November, paunch moisture was reduced from 80 to 30% in five days. With average or above insolation no supplemental desiccant drying was needed. When insolation was 1/3 of average, desiccant usage during 4 of 5 nights supplied 76% of the moisture removal. A tunnel dryer was constructed to measure the drying rate of paunch as a function of relative humidity, depth, and age. The drying rate was highest for a thin layer and low humidity air. Drying was affected most by age at high humidities and least by depth. Air pressure was applied to paunch contained in a 60 liter drum having a screen bottom.
SUPPORTED BY: Oklahoma State Government.

1.0149
DEHUMIDIFYING LIVESTOCK HOUSING USING SOLAR ENERGY TO REGENERATE DESSICANT
Brusewitz GH, Dept. of Agricultural Engineering, Oklahoma State University, *Stillwater Oklahoma, 74075,* (OKLO1787)
OBJECTIVE: Determine the feasibility of using solar regenerated desiccant to dehumidify the winter air in confined animal buildings.
APPROACH: Winter livestock buildings will be dehumidified by passing the air from the animal space through a desiccant at night. During the day solar energy would be used both for heating the building air and for regenerating the desiccant. A computer simulation model will be developed for the moisture sorption characteristics of a solid desiccant during varying input similar to weather conditions. A laboratory prototype adsorption bed/heated air solar collector system will be constructed and tested with a load simulating animal heat and moisture production.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0150
DRYING AND CURING AGRICULTURAL PRODUCTS USING SOLAR ENERGY
Clary BL, Dept. of Agricultural Engineering, Oklahoma State University, *Stillwater, Oklahoma, 74075,* (OKLO1601)
OBJECTIVE: Develop and evaluate practical systems for drying and curing peanut pods using solar energy. Specific objectives are: design and test solar collector. Determine curing conditions for optimum utilization of solar energy, and develop energy storage systems.
APPROACH: The first year of the study proposes design, construction and testing of a solar collector to heat ambient air for direct use in drying peanut pods. Optimum operating conditions will be determined for optimum kernel quality and use of solar energy. Effects of cycling drying air temperature on a diurnal basis as well as reducing maximum drying temperatures as pod moisture content decreases will be studied. Systems and control mechanisms for varying air flow rate through the collector and drying bed as incoming solar radiation changes will be developed. Methods for storing solar energy during periods when incoming energy is not available will be evaluated and developed.
PROGRESS: An 11,000ft (2) pond was covered with six mil polyethylene and supported using air pressures varying between 0.1 and 0.2 inches of water. The pond surface was covered with a layer of black polyethylene to act as an absorber of solar energy. Average temperature of the water continually increased until average pond temperature reached approximately 75 degrees F on November 6,1978. Temperatures measured near the surface of water were as high as 95 degrees F. High temperatures were observed during periods of high solar insolation and decreased during nighttime periods when the pond was losing energy by radiation to the atmosphere. However, water temperatures measured at depths one foot below the water surface were stable and showed a continual increase in temperature throughout the test. On November 6,1978, a cold front passed the site of the experiment and wind velocities increased to 20 m.p.h. At this time one sheet of the polyethylene cover ruptured due to fatigue at one of the folds placed in the plastic during shipping. Because of this failure in the structure the tests were terminated for the 1978 harvest season. In addition to the above test a model study of the fresh water storage system was conducted to determine the efficiency of collection and storage of solar energy in a fresh water pond.
SUPPORTED BY: Oklahoma State Government.

1.0151
SOLAR ENERGY STORAGE FOR DRYING AND CURING PEANUT PODS
Clary BL, Butler JL, Dept. of Agricultural Engineering, Oklahoma State University, *Stillwater, Oklahoma, 74075,* (7091-20191-012-A(2))
OBJECTIVE: Develop and evaluate practical systems for storing solar energy for use in drying and curing peanut pods.
APPROACH: A low cost 2000 sq. ft. flat plate solar collector will be used to heat water from a solar energy storage pond. Approximately 50,000 cubic feet of storage will be used to store the solar energy by elevating the water temperature to approximately 110 degrees F. Storage of heat will begin prior to the drying season, resulting in a storage of approximately 60 million Btu of useable heat at the beginning of the season. This heat energy will be transferred to the drying air stream, through a heat exchanger, and used to dry peanuts from 20-25 percent moisture to a safe storage level of 10 percent or less.
PROGRESS: A pond with 1022m (2) surface area and a maximum depth 1.8 m was covered by 4 quonset type structures each having a clear span of 9.1 m. These were covered with 6 mil Monsanto 602 polyethylene to reduce heat losses from the water. The polyethylene cover was inflated, by two fans, to a pressure of 2.5 mm of water. A black polyethylene film was placed on the surface of the water as an absorber. This failed, becoming brittle and breaking up after about 45 days and was replaced. Overall efficiency of the system ranged from 1/on cloudy days to 42/on clear days. Over a two-month period, the water temperature increased an average of 0.16 degrees C per day. High winds tore the polyethylene cover from the pond, allowing the stored heat to be lost very quickly. Thus, the potential for this type of solar collector/storage appears rather limited.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0152
OPTIMUM BUILDING SYSTEMS FOR AGRICULTURE
Mahoney GW, Kletke DD, Dept. of Agricultural Engineering, Oklahoma State University, *Stillwater, Oklahoma, 74075,* (OKLO1602)
OBJECTIVE: Cost reduction and improved reliability through: development of optimization program for selection of building systems through improved building cost estimation methods, improved structural systems, and design load characteristics for structures and components for agribusiness building systems. Included will be snow and wind loads for Oklahoma, new materials of construction, fastenings and fabrication techniques as applicable to loads and uses, development of basic design and specification for fabrication, assembly and erection or installation as dictated by available labor and equipment to minimize cost.
APPROACH: (1) Analyze need for specific information to meet current or future needs of Oklahoma Agriculture. (2) Determine realistic design load criteria through wind tunnel studies and snow load survey. (3) Conduct model or prototype test for structural systems or components. (4) Analyze costs based on fabrication and erection tests and costs of comparative building systems. (5) Prepare computer program for optimization using data 1 through 4 above, and (6) publish results.
PROGRESS: Computer programs have been completed for determining labor and materials cost for two (2) M.W.P.S. livestock shelters and material costs only for five (5) other livestock shelters. Cost constants will be determined from these programs. Smoke chamber tests for determining bedding drying potential of altered air currents using roof vents has been completed and a paper (OAS P-547) was presented at the ASAE Annual Meeting at Logan, Utah (Paper No. 78-4043, Solar/Air Flow Patterns in Vented Livestock Shelters). Insulated, shot-in-place concrete panels, 21 full size panels, were constructed and tested and test data is being analyzed. A paper on this work will be prepared and presented at the ASAE S.W. Region Meeting in April. A paper was

prepared and presented at ASAE S.W. Region Meeting in Houston in February, 1978 on preliminary results of active solar storage capabilities of greenhouses, OAS Paper No. 489, Self Sufficient Solar Greenhouse. Optimum insulation nomographs were developed for controlled environment buildings and a paper was presented at the ASAE S.W. Region Meeting in February. OAS Paper No. 546, Use of Nomographs to Determine Optimum Insulation.
SUPPORTED BY: Oklahoma State Government.

1.0153
SOLAR HEATING AND ENERGY CONSERVATION FOR GREENHOUSES
Whitcomb CE, Paine M, Mahoney GW, Dept. of Horticulture, Oklahoma State University, *Stillwater, Oklahoma, 74075,* (OKLO1690)
OBJECTIVE: Develop and field test economical solar heated greenhouses containing their own heat storage system until the basic design criteria are stabilized. Experiment with pot and air temperatures until the minimum allowable soil and air temperature combinations are determined for the major horticultural crops. Develop a heat conversion system for night-time operation until a heat loss reduction of 7 is routinely achieved. Develop the controls, sensors and actuators needed to secure optimum efficiency from the solar heating and storage system.
APPROACH: An improved greenhouse incorporating the lessons from the initial greenhouse will be built and instrumented. The original greenhouse will be converted to a gas heated greenhouse and used for comparison purposes. Grow an assortment of cultivars of the major greenhouse crops (Chrysanthemums, Poinsettias, tomatoes, and others) with known greenhouse temperature requirements in both the solar and gas heated greenhouses. A programmable controller will be installed in the improved greenhouse. The controller allows flexible rearrangement of the connections between inputs (thermostats, pressure sensors) etc.
PROGRESS: A solar greenhouse was constructed during August, 1976, which captured the heat accumulated between two air inflated layers of clear polyethylene. The heat was stored in a sand-water layer beneath the floor. In 1978, the collection system was abandoned in favor of an inexpensive flat plate type collector constructed from galvinized corrugated steel. The water-sand heat storage beneath the floor was retained. The bottom heat provided plants growing on the floor appears to be more efficient than air heating systems although differences among cultivars of poinsettia and chrysanthemum were noted. Poinsettia cultivars Annette Hegg, Lady, Wonder Star and V-10 grew well with bottom heat to the containers but cool air temperatures while Top Star, C-1 and Jingle Bells were less suited to the cooler air temperatures. Chrysanthemum cultivars Winter Carnival, Altis, Puritan, Copper Anne, Bright Golden Ann, Spinwhell, Garland, Copper Bowl, Yellow Mandalay, Mountain Snow and Gold Star performed well whereas Intrepid Good, Velvet Ridge, Senorita, Gem, Pink Glo, Yellow Paragon, Royal Purple and Wild Honey were less satisfactory in the solar house.
SUPPORTED BY: Oklahoma State Government.

1.0154
DESIGN AND TEST OF A PASSIVE SOLAR COLLECTION, STORAGE, AND DISTRIBUTION MODULE
Bliege CL, Dept. of Engineering, HITEK Inc., *Sweet Home, Oregon, 97386,* (DOE 80-20)
OBJECTIVE: Passive Thermal Battry Module Prototypes are to be designed, fabricated, and tested. These modules will be able to collect, store, and distribute solar energy, in passive and/or hybrid operation modes. A prime objective is to use phase change materials which are available on the market, and design the module to allow use of several different phase change materials or package configurations. Initially, heat transfer characteristics of various PCM packages will be analyzed. These will be analyzed from a passive collection and storage aspect and a passive/hybrid distribution aspect. The module design will consider broad market application. It will be optimized for performance, installation, shipping and handling. Applications will include new and retrofit installations behind south facing glass, and solar greenhouses in either residentail or commercial applications. Full application information will be developed in future phases of the project:
SUPPORTED BY: U.S. Dept. of Energy.

1.0155
ASSESSMENT OF TECHNOLOGY IN THE FOOD AND FIBER SYSTEM
Miller ME, National Economic Div., U.S. Dept. of Agriculture, Economics & Statistics Service, *Philadelphia, Pennsylvania, 19118,* (NEA-12-107-42-04)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Solar energy applications research continued with data gathering and consulting with SEA/AR and SAES engineers. The major applications were tobacco irrigation, peanut drying, and greenhouse heating. Solar powered irrigation was also studied but not as intensely as the other areas. The feasibility of feeding crop residues to beef cattle was studied. The study inventoried residues on a county-by-county basis, estimated the economic values of residues, and identified the economic effects of reducing grains and increasing forage and residues. Data were gathered to compare trends in technology and productivity in processing and distribution. Uses of agricultural products in manufactured goods were identified.
SUPPORTED BY: Dept. of Agriculture, Economics & Statistics Service.

1.0156
ENERGY CONSERVATION SYSTEMS FOR GREENHOUSES
Walton HV, White JW, Dept. of Agricultural Engineering, Pennsylvania State University, *University Park, Pennsylvania, 16802,* (PEN02194)
OBJECTIVE: Design, build and evaluate thermal insulation systems for use in greenhouses. Design, build and evaluate a greenhouse structure and environmental control system for efficient use of solar energy. Design, build and evaluate solar energy storage and recovery systems for use in greenhouses.
APPROACH: Materials with potential for reducing heat loss from greenhouses during dark periods will be evaluated by sample testing and analysis. Structural panels with high thermal resistance (R>10) will be fabricated and tested to determine their mechanical and heat transfer properties. Structural systems will be designed that will satisfy solar energy transmission requirements during light periods and heat conservation practice during dark periods. The structural and environmental systems will be evaluated as greenhouses based on their potential for conserving thermal energy, for using solar energy for heating, and for crop production. Solar energy storage and recovery systems will be designed, built and tested to determine their potential for conserving fuel and providing for environmental control in greenhouses.
PROGRESS: Computer programs developed under the project showed that the greatest potential for fuel saving was from combined insulation and solar heat. Double layer glazing and aluminized thermal blankets combined with internal solar collectors reduced fuel requirements as much as 90% of the requirement for conventional commercial Pennsylvania greenhouses. Calcium chloride hexahydrate, encapsulated in steel aerosol cans, performed adequately as a phase change storage medium for externally and internally collected solar hot air. About 8% of the yearly greenhouse heat requirements can be supported from solar collectors sized at one square foot of collecting surface for each two square feet of floor area. Solar air collectors produced a clear day average of 6.03E06 J/m using a 0.03 m /s-m air flow rate and a 58 tilt angle in May. The internal excess heat collection system provided a clear day average of 1.23E06 J/m using a 0.003 m /s-m air flow rate. An infrared heating system plus thermal blanket showed a potential saving to 50% over conventional hot water systems. Continuing research relating crop response to IR heat plus soil heat is in progress.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0157
HEATING COMMERCIAL GREENHOUSES WITH SOLAR ENERGY
White JW, Butler JL, Dept. of Horticulture, Pennsylvania State University, *University Park, Pennsylvania, 16802,* (7004-20690-017A(1))
OBJECTIVE: Design, test, and evaluate greenhouse structures, various greenhouse solar heating systems, and environmental control systems for efficiency of use of solar energy for greenhouse heating and plant growth.
APPROACH: Construct a seventh greenhouse of two-barrel vault design with a double-layer air inflated polyethylene cover, using one greenhouse as a control with a standard fossil-fuel heating system, compare various active and passive solar heating systems in the other six. Vary the solar systems so as to compare solar collection external and internal to the greenhouse, use of solar heated water or solar heated air, and rock and water heat storage systems. Install thermal blankets either thin (L 6 mil) or thick (G 6 mil), and compare their effectiveness. Monitor energy use and environmental parameters and correlate with system designs and evaluate plant response to the environments produced by each solar heating system.
PROGRESS: Performance of six experimental greenhouses is being monitored. Three are fiberglass glazed, one with double wall extruded acrylic, one with double wall extruded polycarbonate, and one with single layer glass. Three have water solar collectors with combination water-rock storage, one has water collection and storage, one has air collection and rock storage, one has internal collection with air to rock storage. All the greenhouses have internal thermal blankets. Data suggests internal collection can supply less than 10% of annual heat required. A simulation study showed that thermal blankets can reduce fuel use in a glass greenhouse by 50% or more and fuel costs by almost 40%. The same study showed that solar collectors can further reduce fuel requirements but will not reduce heating costs. Several horticultural crops were grown in the houses. Horticultural performance of the glass greenhouse under stress conditions of 30 degrees C day and 5 degrees C night reduced yield of lettuce by 20 to 50%. Whereas yields in the other greenhouses, when operated under stress conditions for energy conservation, equaled yields of controls because of the thermal buffering effect of double glazing and thermal storage under beds.
SUPPORTED BY. U.S. Dept. of Agriculture, Agricultural Research.

1.0158
QUALITY HOUSING ENVIRONMENT FOR LOW-INCOME FAMILIES
Allen WH, Dept. of Agricultural Engineering, Clemson University, *Clemson, South Carolina, 29631,* (CS00091)
OBJECTIVE: Identify housing needs and satisfactions of low-income families and examine limitations to the attainment of quality housing. Formulate and evaluate innovative delivery systems in production, marketing, and financing in order to improve housing conditions. Formulate and evaluate innovative techniques and delivery systems for the transferral of housing information.

APPROACH: Community provisions and limitations to the attainment of quality housing will be investigated. Findings will be shared with architects, economists, environmentalists, planners, engineers, and with extension workers. Identification of the decision-makers in the provision and acceptance of low-cost housing innovations, including low-income families. Determine the kinds of housing information needed by low-income families. Transfer information to decision-makers in the housing industry at various levels including low-income families. Evaluate existing constraints to change and/or improve delivery systems for providing the housing product to low-income families.
PROGRESS: A panelized, free-standing solar powered domestic water heater was tested under actual domestic use conditions and the performance evaluated for a period of time under "summer" conditions. Operating costs were almost negligible although significant fixed costs combined to produce a total cost per gallon in excess of estimated costs for a conventional electric water heating system. A computer simulation model was developed to predict the performance of the solar water heater prototype. Interrelationships between efficiency, capacity, consumption rates, and water consumption patterns were developed by the model.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0159
HOUSING FOR LOW--AND MODERATE--INCOME FAMILIES
Allen WH, Dept. of Agricultural Engineering, Clemson University, *Clemson, South Carolina, 29631*, (SC00366)
OBJECTIVE: Provide innovative designs and research assistance for the construction of prototype housing systems and subsystems and for rehabilitation of existing housing and review and evaluate them by interdisciplinary teams.
APPROACH: Energy efficiency, consumer acceptance, overall system performance and system component performance will be determined for each of two solar prototype homes located on the Clemson University campus. One is an earth insulated home while the other is a "greenhouse" home. Clemson University (SCAES) and RHRU-SEA-USDA are cooperating in the research activities.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0160
OPTIMIZE EFFICIENCY OF ENERGY UTILIZATION IN AGRICULTURAL HOUSING SYSTEMS
Allen WH, Dept. of Agricultural Engineering, Clemson University, *Clemson, South Carolina, 29631*, (SC00410)
OBJECTIVE: Increase efficiency of energy utilization in agricultural housing systems through development and evaluation of technological and management alternatives. Develop energy-efficient design criteria for agricultural housing systems.
APPROACH: The technical and economic feasibility of the application of heat pumps and other alternative energy sources including solar energy and of energy conserving techniques such as exhaust heat recovery to develop efficient heating systems will be determined. The effectiveness of high density brooding of chickens to 3.5 weeks of age will be evaluated for conservation of energy. Inter-relationships between brooding density, ventilation rates and energy consumption will be investigated.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0161
SOLAR ENERGY FOR HOME HEATING
Allen WH, Ezell DO, Dept. of Agricultural Engineering, Clemson University, *Clemson, South Carolina, 29631*, (SC00307)
OBJECTIVE: Determine the daily energy requirements of two solar heated structures; the effectiveness of the solar energy collectors; the adequacy of the architectural design and solar heating systems in achieving a favorable living environment; the productive potential of the solar-heated greenhouse for supplying all or part of the food supply of the structure's occupants; the cost and energy savings (including costs of construction, heating and cooling, maintenance and food), if any, resulting from the designs used in the structures.
APPROACH: Two solar heated houses, one earth insulated and the other with an attached greenhouse, will be constructed. A study will be made of the design, construction methods, and energy efficiency of the structures. Instrumentation will be installed to monitor heat loss and other environmental factors prior to occupancy. Studies will continue during occupancy.
PROGRESS: A solar greenhouse residence (GHR) and a solar earth insulated home (EIH) were constructed on the Clemson University campus and occupied in December, 1978. Instrumentation was completed and data collection initiated in the GHR in December, 1978. Instrumentation is not expected to be complete in the EIH until February, 1979, although some data collection started in December. The greenhouse portion of the GHR was stocked with plants in October, 1978 and is proceeding very successfully. Two "open house" events were very successful. Questionnaires regarding public reactions to the homes were completed by several hundred visitors and collected for analysis by an interdisciplinary team of scientists.
SUPPORTED BY: South Carolina State Government.

1.0162
ENERGY REDUCTION FOR ON-FARM PROCESSING OF AGRICULTURAL PRODUCTS
Bunn JM, Allen WH, Dept. of Agricultural Engineering, Clemson University, *Clemson, South Carolina, 29631*, (SC00409)
OBJECTIVE: Develop new energy efficient systems for processing agricultural products.
APPROACH: The technical and economic feasibility of a solar supplemented heat pump for drying grain will be determined. The system will be applied as a multiple-use energy source for space heating/cooling and for crop drying. Computer simulation will be used to develop an optimum design, operational mode and duty cycle. The unit will be evaluated for performance and crop quality under a typical farmstead situation.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0163
SOLAR ENERGY AND WASTE HEAT UTILIZATION WITH GREENHOUSE/RESIDENCE COMBINATION
Ezell DO, Butler JL, Dept. of Horticulture, Clemson University, *Clemson, South Carolina, 29631*, (7007-20690-020-A(1))
OBJECTIVE: Develop, test, and evaluate designs for greenhouse-residence combinations that will conserve energy and optimize use of solar energy for supplemental heating of both structures, and provide space for production of family vegetable needs.
APPROACH: Complete construction of two additional prototype residences with attached greenhouses. Instrument, test, and evaluate these prototypes and continue tests of first prototype to determine the value of attached greenhouses in modifying the heating and cooling needs of associated residences and in supplying family food needs. Develop optimum vegetable production program for the greenhouses. Refine, modify, and improve plans for greenhouse-residence combinations based on construction feedback and costs, operation of mechanical systems, and on greenhouse food production data.
PROGRESS: Two additional solar greenhouse-residence prototypes were built and performance is being monitored for three such prototypes. The horticultural performance of the two new prototypes is being carefully monitored and various methods of insect control tested. Plastic glazing under glass used in the first prototype collector needs replacing after two years of operation. The second prototype has a collector built with glass cover and double layer metal absorber. The third prototype uses only the greenhouse as a solar collector with glass over plastic. Total construction cost of each prototype was higher than expected. Improvements in attached greenhouse and collector design increased solar heating performance by 8%. Final construction plans are being prepared which include details of improvements, in greenhouse, solar collector, and air distribution system, and which include features designed to reduce cost. Cost of solar heating system with integrated greenhouse will add from 15 to 20% to total construction cost.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0164
BUILDING AND UTILITY SYSTEMS TO REDUCE COSTS OF HOUSING FOR LOW-INCOME RURAL FAMILIES
Newman JO, U.S. Dept. of Agriculture, Agricultural Research, Clemson University, *Clemson, South Carolina, 29631*, (7708-20690-001)
OBJECTIVE: Reduce costs of components of building systems, including construction methods and materials, utilities and waste handling to lower initial and operational costs of housing for low-income rural families while improving livability and acceptability.
APPROACH: Develop innovative structural systems, construction techniques, and utilities, including heating, cooling, plumbing and electrical systems, that have potential for reducing initial or operational costs of housing structures, Test and evaluate these in-laboratory and in-prototype structures (in cooperation with other housing agencies). Investigations will include panelized construction techniques, new building materials, optimum mixes and combinations for building blocks and wall panels utilizing inexpensive or waste materials, heating and cooling with various forms of energy including solar energy, simplification of plumbing systems and improvement of waste control systems.
PROGRESS: Rural Housing Research Unit has concentrated on development and evaluation of greenhouse-residence, solar-earth house, and small community sewage projects. Greenhouse-residence was monitored to document parameters and to determine overall performance. Data were acquired and reports were completed for January through April and Dec. 1979. Initial performance was lower than anticipated due to undersized air handler and low quality dampers. A two-blower system has been designed with high quality dampers to reduce leakage and increase collector air flow. Studies were continued in the greenhouse-residence on both the vegetable production and energy performance showing that $250 per year of vegetables can be produced. Data indicates that excessive energy was required to maintain growing conditions at night when warm season vegetables are grown during colder months reducing energy collection efficiency. Solar-earth house tests showed that earth-insulation alone was not sufficient to control the house energy requirements (heat-loss often more than through well-insulated exposed walls) but they have also showed that small amounts of man-made insulation pays large dividends reducing heat loss to between 1/10 to 1/4 of that through the same exposed wall without earth insulation. Analysis showed building cost below grade were 10% less than similar houses built above grade and energy cost may be reduced by 50% or more.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0165
SOLAR HEATING SYSTEM FOR THE FIRST BAPTIST CHURCH OF ABERDEEN SOUTH DAKOTA
Unknown, First Baptist Church, *Aberdeen, South Dakota, 57401*, (EG-77-A-03-1510)
Summary Information has not been provided.
SUPPORTED BY: U.S. Dept. of Energy.

1.0166
LIVESTOCK CONFINEMENT AND ENVIRONMENTAL CONTROL SYSTEMS RELATIONSHIPS WITH CLIMATE AND ENVIRONMENT
Hellickson MA, Moe DL, Dept. of Agricultural Engineering, South Dakota State University, *Brookings, South Dakota, 57006,* (SD00753)
OBJECTIVE: Investigate the interrelationships between environmental conditions, climatic conditions, confinement facility design, environmental control equipment design, system management, and livestock performance. Evaluate the effects of confinement system design on ambient temperature, relative humidity, ventilation characteristics, and other selected environmental. parameters. Investigate ventilation system performance and design in selected livestock eonfinement facilities commonly used in South Dakota. Monitor water quality in selected South Dakota lagoons.
APPROACH: Computer simulation techniques will be employed to investigate the relationships between housing design, environment, climatic conditions, and environmental control equipment design. Emphasis will be on determining specific insulation, ventilation and heating system designs. Scale models and wind tunnel studies will be employed to evaluate the performance of confinement livestock building ventilation systems.
PROGRESS: Model studies of open front beef buildings indicate that size of ridge vent opening is indirectly related to outlet velocity for northwest winds, assuming the long closed side of the building is to the north. However, total flow through the ridge vent was directly related to ridge vent opening size. For winds from the north ridge vent size had less influence on outlet velocity than was noted for the northwest wind and again ridge vent flow was directly related to outlet size. Significant, linear relationships for predicting outlet velocity based on wind velocity were developed for all model test conditions. A solar energy intensifier-thermal energy storage system showed excellent potential for providing supplemental heat for a swine finishing building. The 45.7 m(2) solar system provided the energy equivalent of $2.05 worth of electricity per day.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0167
SOLAR ENERGY SYSTEM TO HEAT AIR FOR SWINE SHELTERS AND GRAIN DRIERS
Hellickson MA, Winter DW, Dept. of Agricultural Economics, South Dakota State University, *Brookings, South Dakota, 57006,* (7003-20400-015A)
OBJECTIVE: Develop design criteria for a multi-purpose, diurnally-tracking solar intensifier to improve the energy collector system for swine shelter heating and corn drying.
APPROACH: Design and build a solar energy system, consisting of a two-sided collector, a diurnally tracking, seasonally adjusted curved reflector and a native stone heat sink. Test system on swine shelters and on corn drying. Obtain system performance under local conditions and determine economic feasibility for simple and multiple use.
PROGRESS: A solar energy intensifier-thermal energy storage system was designed and developed for in-storage grain drying and for providing supplemental heat for livestock buildings. The 45.7 m (2) solar system collected 45.6% of the energy perpendicular to the system during the drying study. This amounts to a monetary equivalent of 2.7 /m (2)/day. The above system operated at an average efficiency of 37.3% during the heating study, which employed a lower air flow rate. Overall solar system performance was reduced due to an excessive air flow path through the collector. A new collector design was developed and is expected to improve system performance. A system for evaluating the cost/performance charcteristics of agricultural solar collectors was developed, based on life cycle casting, climatic variables and solar system performance characteristics. A micro-processor system has been obtained and programmed for use in data collection and analysis. Addition of this system will allow on-site and essentially instantaneous determination of the performance characteristics of the solar energy intensifier-thermal energy storage system.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0168
ENERGY EFFICIENCY AND UTILIZATION IN AGRICULTURAL PRODUCTION
Hellickson MA, Young HG, Peterson WH, Dept. of Agricultural Engineering, South Dakota State University, *Brookings, South Dakota, 57006,* (SD00754)
OBJECTIVE: Evaluate systems for more efficient use of electricity, fossil fuels, and other energy sources for agricultural production. Determine the energy requirements for performing selected agricultural operations in South Dakota. Investigate methods of substituting energy sources, such as, solar and wind, for agricultural systems currently using conventional energy sources. Study the effects of management and control on energy use for agricultural production.
APPROACH: Cold air crop drying and solar supplemented crop drying studies will be conducted on the Agricultural Engineering Farm. Low temperature, low cost solar collectors will be investigated as a source of supplemental heat for confinement livestock buildings. Work will be performed to develop a multi-purpose solar-intensifier-thermal storage system for agricultural uses.
PROGRESS: A solar energy intensifier-thermal energy storage system was designed and developed for in-storage grain drying and for providing supplemental heat for livestock buildings. The 45.7 m(2) solar system collected 45.6% of the energy perpendicular to the system during the drying study. This amounts to a monetary equivalent of 2.7 cents/m (2)/day. The above system operated at an average efficiency of 37.3% during the heating study, which employed a lower air flow rate. Overall solar system performance was reduced due to an excessive air flow path through the collector. A new collector design was developed and is expected to improve system performance. A system for evaluating the cost/performance characteristics of agricultural solar collectors was developed, based on life cycle casting, climatic variables and solar system performance characteristics. A summary of Eastern South Dakota farmers revealed regional influences on consumption of gasoline, P(2)0(5) and K(2)O for small grains. Energy consumption in the form of chemicals and fertilizers, when compared by crop, indicated corn and small grains were energy intensive crop types. A micro-processor system has been obtained and programmed for use in data collection and analysis. Addition of this system will allow on-site and essentially instantaneous determination of the performance characteristics of the solar energy intensifier-thermal energy storage system.
SUPPORTED BY: South Dakota State Government.

1.0169
PREPARATION, PRESERVATION AND STORAGE OF LIVESTOCK FEEDS
Luther RM, Embry LB, Bush LF, Dept. of Animal Science, South Dakota University, *Brookings, South Dakota, 57006,* (SD00738)
OBJECTIVE: Determine effects of type of preparation, use of various preservatives, and method of storage on rate of gain, feed consumption, and feed efficiency of cattle and sheep under various feeding systems, digestibility, rumen fermentation and energy value of feeds and keeping qualities and nutrient losses during storage.
APPROACH: This project will involve a series of feeding trials using cattle and sheep along with digestion and metabolism experiments. The initial research will study the feeding value of corn grain harvested at high moisture and artificially heat dried, stored and dried with solar heat or treated with an organic acid preservative. Later studies will involve other high-moisture grains and the effects of preservatives and feed additives at time of storage or at the time of feeding with grains, forages and crop residues. Emphasis will be on making maximum use of grain and forage crops and residues for production of beef cattle.
PROGRESS: Whole, rolled, and pelleted oat grain were compared in finishing diets for beef steers. In one trial steer gains were 10.5% faster and were 11.6% more efficient with rolled oats over whole oats. In a second trial steer gains were about the same for whole, rolled and pelleted oats in early phases of the feeding trial, but weight gains were sharply reduced toward the end of the feeding period. Carcass measurements were collected and two digestion rumen fermentation trials were conducted. The data are being summarized. An experiment was conducted with oat forage harvested as haylage or as baled hay. Yearling steers gained faster and more efficiently when fed oat haylage than when fed oat hay. Losses of dry matter between storing and feeding amounted to .65% for oat hay and 10.6% for oat haylage. Haylage dry matter losses during storage in a concrete stave silo were 10 to 12%. Haylage made from weed crops (lambsquarters and kochia) were compared with oat haylage in a growing trial with cattle and a finishing trial with lambs. Weed crop haylage had a feeding value of 47% that of oat haylage when the haylage comprised the major portion of the diet for growing cattle. When weed haylage was fed to finishing lambs at 40% of the diet, the feeding value of haylage was about 80% that of oat haylage. Corn silage and corn stover silage were treated with a nitrogen additive, a microbial culture and with an organic acid preservative and stored in small experimental silos.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0170
IMPROVING LARGE DAIRY HERD MANAGEMENT PRACTICES
McGuffey RK, Dept. of Dairy Science, South Dakota State University, *Brookings, South Dakota, 57006,* (SD00860)
OBJECTIVE: Investigate ways of increasing the efficiency of producing dairy replacements in large herds. Improve animal performance and increase labor efficiency.
APPROACH: Various designs of calf hutches will be studied to determine the most efficient for providing added heat from solar energy. Calves three days of age will be housed in regular or solar-heated calf hutches and weight gain, feed intake and health determined. Physiological adaptation of young calves to extreme termperatures will be studied. Four free stall surfaces will be compared as to cow utilization and preference as well as labor requirements for cleaning and maintenance.
PROGRESS: A study feeding fermented antibiotic containing mastitic milk to dairy calves was completed. Calves fed fermented mastitic milk had similar weight gains to those fed whole milk. There was a 3-fold increase in incidence of diarrhea and respiratory problems in calves fed fermented mastitic milk, but mortality was similar for both groups.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0171
COST COMPONENTS FOR PRODUCING, PROCESSING, AND HANDLING GRAIN
Ullrich EO, U.S. Dept. of Agriculture Commodity Economics Div., South Dakota State University, *Brookings, South Dakota, 57006,* (CE-04-032-46-01)
OBJECTIVE: Estimate cost components by geographic areas for all phases of production, processing, and handling of grain. Develop a system for maintaining and updating cost data.
APPROACH: Estimate cost component data needed in the overall analysis of the grains subsector. Develop and coordinate a system of cost data that would be linked internally in grains sector and externally with other commodity sectors.
PROGRESS: Support was provided to the FEDS on cost of producing grain crops and specifying typical grain farms. Work continued on price spreads and costs components for bread. The agency's energy activity was supported with the publication of a conservation manual for field crops and economic evaluation of solar energy used for grain drying.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

1.0172
CURING, STORING AND FEEDING HIGH VALUE HAY IN LARGE PACKAGES
Bledsoe BL, Dept. of Agricultural Engineering, University of Tennessee, *Knoxville, Tennessee, 37916,* (TEN00057)
OBJECTIVE: Develop a swath inverting method for rapid solar drying of both sides of wide, thin hay swaths. Determine requirements for in-field drying of large round hay bales by axial ventilation. Develop storage racks and hay bunks for large hay packages that provide adequate air circulation and minimum losses.
APPROACH: A method for measuring amount of hay swath inversion based on temperature or color differences in the top hay surface will be developed. An experimental machine to pick up and move the wide, thin swath in a helical pattern to accomplish the inversion will be designed, built, and tested. Axial ventilation effect on hay package drying rate will be determined using a previously built piercing machine to form the ventilating passages. Minimum-cost storage racks for large hay packages and hay bunks with movable gates for effective feeding will be designed, built, and evaluated.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0173
DRYING LARGE HAY PACKAGES WITH SOLAR HEATED AIR
Bledsoe BL, Butler JL, Dept. of Agricultural Engineering, University of Tennessee, *Knoxville, Tennessee, 37916,* (7006-20190-018-A)
OBJECTIVE: Design, construct, and test a modular dryer using solar heated air.
APPROACH: Basic module will be designed and installed into an existing multi-purpose pole barn. The module will have collector area and storage capacity to dry thirty 360-kg (800-lb) hay bales from 40 percent to 20 percent moisture content in 2 days or less. The dryer configuration will allow loading and unloading of bales without special handling equipment. The system will be evaluated by comparing solar dried haymaking with conventional haymaking (300-400 metric tons/year) and by drying corn (production from 40 ha/year) and providing heat for the machine repair storage area.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0174
EVALUATION OF SELECTED PHYSICAL PROPERTIES AFFECTING HANDLING OF TENNESSEE VEGETABLES
Wilhelm LR, Dept. of Agricultural Engineering, University of Tennessee, *Knoxville, Tennessee, 37916,* (TEN00494)
OBJECTIVE: Develop reliable physical properties data for selected Tennessee vegetables. Apply the air flow data developed in this project to the design and operation of ventilation cooling equipment for bulk cooling of vegetables being held for processing. Make these data available in a form which can be readily used in the design of bulk harvesting, handling, and transportation equipment.
APPROACH: Air flow resistance data, mechanical property data, and moisture measurement analyses will be made for several vegetable products. Resistance to air flow studies will be emphasized for snap beans, lima beans and southern peas. These tests will be coordinated with existing production research to insure full and effective use of the vegetables produced by those projects. Construct a bulk cooling system based upon the air flow data obtained. Test the system in cooperation with one or more Tennessee processors to evaluate its effectiveness in commercial applications. Present the results obtained in parts 1 and 2 at professional meetings and prepare the data for publication in appropriate technical publications.
PROGRESS: Measurement of resistance to air flow for bulk southern peas was continued and tests were initiated for lima beans. Tests indicate less satisfactory results than those obtained with earlier snap bean tests. Other factors such as product size and void space are being studied to improve the correlation. As with snap beans, the correlation can be improved by including the bulk density in a dimensionless pressure term. Peas appear to have pressure drop characteristics very similar to snap beans while lima bean data show a slower increase in pressure drop with air flow. Three new solar dryer models were constructed and tested for apple drying. These half-scale models were tested n conjunction with a solar dryer and an electric dryer used in previous tests. All solar dryers appeared to work satisfactorily, although analysis of the data is continuing. Several varieties were used during these tests to determine the preferred varieties for drying. Analysis of these samples has not been completed. Limited tests of home oven drying are continuing to evaluate this method with respect to energy cost and product quality. Preliminary results indicate that energy costs are significantly higher when home ovens are used. Moisture measurement techniques for vegetables have been studied using snap beans as the test product.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0175
DRAPERIES FOR THERMAL COMFORT AND ENERGY CONSERVATION
Vigo TL, Hassenboehler CB, Textiles Clothing Research, U.S. Dept. of Agriculture, *Knoxville, Tennessee, 37916,* (7806-20860-015)
OBJECTIVE: Develop prototype draperies to optimize solar radiation and heat transfer at windows.
APPROACH: Employ window enclosures which effect temperature differences in winter and/or summer climates. Design and evaluate drapery prototypes which function as low temperature solar heat collectors and/or solar heat reflectors whereby thermal energy may be absorbed by or transferred from living spaces efficiently in winter and summer climates, respectively. Utilize laminates, coated fabrics, and other textile structures in draperies to produce desirable heat transfer properties and other characteristics important for achieving overall energy conservation on a seasonal level. Measure utility of drapes in relation to optimization of total energy transfer to living space and effects on occupant comfort parameters.
PROGRESS: Commercially available drapery materials (e.g., 60/40 rayon/acetate lined drapes) were used to construct drape models which reduced heat flow through windows by 50%. All tests were done on a simulated winter window site. Heat flow through the window was monitored by a minicomputer and measured with voltage-producing heat flow transducers attached to the window. Thermal transmittance values ranged from a high of 1.0 (bare window) to a low of 0.5 Btu/hr ft (2) degree F for the most energy-efficient drape configuration (corresponding to R-values of 1.0 and 2.0). Conventional drapes normally require full closure to effectively reduce heat flow; however, for winter conditions, the top edge of the drapes can be well separated from the wall and still limit heat flow. This "open bag" principle was applied to develop basic "energy drape" concept. Prototypes of the "energy drape" were configured from one or two basic elements: lined 60/40 rayon/acetate drapes, and unlined 60/40 rayon/acetate drapes. To fabricate drape assemblies efficient for reducing heat flow, and maximizing thermal comfort, one or two elements were hung by a separate rod and sealed to the wall along the sides and bottom of the window ("open bag" concept). The outer layer was hung in a conventional manner and did not need to be sealed to impede heat flow.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0176
SOLAR DRYING AND LONG-TERM STORAGE TECHNIQUES OF ROUGH RICE
Calderwood DL, Rice Research, U.S. Dept. of Agriculture, Agricultural Research, *Beaumont, Texas, 77704,* (7303-20590-003)
OBJECTIVE: Determine a better method of extracting solar heat from a rock bed. Investigate the effect of high plenum temperatures from solar heat in deep-bed dryers on drying time and on rice quality. Adapt solar heat to reduce fuel requirements of a continuous-flow dryer. Evaluate techniques, including aeration, for maintaining rough rice market quality during a storage period of several years.
APPROACH: A system for applying solar heat to a rock bed in the daytime and extracting the heat at night will be improved so as to provide a uniform plenum temperature for a deep-bed rice dryer. Larger and more energy efficient solar collectors will be tested for applying solar heat to deep-bed dryers immediately as collected to determine the optimum ratio of solar collector surface area to dryer capacity. A solar collector array will be installed on a 1000 sq. ft. roof to provide some of the heat for a continuous-flow drying operation. Observations of rice storage conditions in a 20-bin facility will be made periodically during a long-term storage period through temperature, moisture content and milling quality determinations.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0177
PREDICTION AND CONTROL OF WATER USE EFFICIENCY IN CROP PRODUCTION
Van Bavel CH, Dept. of Soil & Crop Science, Texas A & M University, *College Station, Texas, 77843,* (TEX01754)
OBJECTIVE: Combine available crop water use efficiency model with water conservation through a mulching model, applicable to irrigated and dryland cultivation. Test water conservation segment of model under field conditions of high plains area. Compute effects of specific plant parameters on water use efficiency for different climatic zones in Texas. Verify root water uptake segment of model under controlled environmental conditions. Measure pertinent plant properties that influence water use efficiencies.
APPROACH: Modeling work will employ dynamic simulation methods, mainly in combining existing segments of models derived earlier, using actual climatic data for different crop regions. Field tests to utilize standard weather data and soil moisture inventories to verify predicted water storage. Plant parameters to be used and measured are stomatal sensitivity, resistance to water flow and carbon dioxide utilization efficiency.
PROGRESS: A combination of experimental work on soil water availability to crop root systems is being planned following the previous year's work with soybeans. A split-root system technique was devised and the environmental control system partially modernized in preparation for a series of tests of a model proposed earlier. A major effort with definitive results was obtained in a controlled environment study of the effect of soil water deficits upon the efficiency of growth (synthesis) and upon the maintenance cost of grain sorghum through a carbon balance analysis. The synthesis efficiency remained constant with rising deficits while the maintenance cost per unit dry matter decreased slightly. The result can be applied to predicting the effect of drought on grain yield. Further work in analysis and experiments on the water requirements in a fluid-roof solar greenhouse is now being conducted.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0178
CONTROL OF PLANT ENVIRONMENT IN FLUID-ROOF SOLAR GREENHOUSE
Van Bavel CH, Butler JL, Dept. of Soil & Crop Sciences, Texas A & M University, *College Station, Texas, 77843,* (7709-20690-022A(1))
OBJECTIVE: Determine the feasibility of using thin film of selected fluids in the roof of a greenhouse to selectively absorb and store for later use solar radiation not useful in photosynthesis by greenhouse plants.
APPROACH: Construct a dynamic simulation computer model that describes the energy disposition in a solar greenhouse with a fluid roof that is selectively transparent for photosynthetically active radiation. Evaluate the potential energy savings and other advantages of such a solar-heated, fluid-roof greenhouse. Add fluid circulation and storage to an existing greenhouse (23 m(2) floor area) and install instrumentation to provide data for testing adequacy of model as well as comparison of effectiveness of various selective fluids.

PROGRESS: A simple model of the fluid-roof solar greenhouse was expanded to include the storage of heat in the soil, and to account for multiple reflections of shortwave radiation between the roof and crop. A partial validation of the model, for a greenhouse without fluid in the roof, was executed. The experimental greenhouse was instrumented to collect the data necessary for input to the model, and the data necessary for comparison with the model predications. Four test days were selected, of which the final evaluation was completed. Predicted values were quite close to measured ones with the same exceptions. The ventilation rate per day is underestimated. This is a direct consequence of the underestimation of the air temperature. It was also found that roof temperature cannot be reliably measured with a thermocouple during the daytime. The nighttime roof temperatures were estimated very well, but the radiation incident on the thermocouple caused the indicated temperature to be much higher than the rest of the roof. Three additional versions of the greenhouse model were developed. The first included a system by which heat was exchanged between the fluid storage tank and underground water. The second included a heater placed in the soil. The third included provisions to drain the roof at night, and to circulate the fluid through a system of plastic tubes on the soil surface for heating. This work is still in progress.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0179
FEASIBILITY STUDY OF SOLAR HEATING SYSTEMS FOR VERMONT DAIRY PRODUCTION
Wells GD, Dept. of Vocational Education & Technology, University of Vermont, *Burlington, Vermont, 05401*, (VT00915)
OBJECTIVE: Observe effects of environment and management on construction, materials, and system components; determine effectivness of thermal mass walls for solar heat storage for livestock shelters; estimate cost effectiveness.
APPROACH: Five different solar systems will be monitored on 5 different farms in Vermont. Systems will be monitored on 2 calf barns, one milking center, one dairy goat farm, and one small general farm. Four systems will include passive thermal storage solar systems and one will be an active system.
SUPPORTED BY: Vermont State Government.

1.0180
COMBINATION DRYING OF GRAIN USING SOLAR ENERGY
Baker JL, Hartsock JG, Dept. of Agricultural Engineering, Virginia Polytechnic Inst. & State University, *Blacksburg, Virginia, 24061*, (3090-20592-031-G)
OBJECTIVE: Develop a combination drying system utilizing solar energy suitable for use in the humid Southeast. Develop solar collector designs suitable for installation in farm building roofs which will be economical, have long life, be useful for multiple applications, and be easily constructed. Evaluate and demonstrate such combination systems for drying crops under humid conditions.
APPROACH: Select two farmsteads having or planning high-temperature drying systems and storage bins and alter or build these into combination systems incorporating solar drying. Design and build solar collectors integrated into south-sloping roofs. Design criteria shall be 15-yr useful life, material costs of less than $2/sq. ft. of area, and average efficiency of at least 50% when used for grain drying. Construction will be possible by farmers or farm builders. Evaluate and demonstrate the use of solar energy in grain drying applications.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0181
WASTE SYSTEMS AS SOLAR ENERGY RESERVOIRS
Vaughan DH, Bell ES, Dept. of Agricultural Engineering, Virginia Polytechnic Inst. & State University, *Blacksburg, Virginia, 24061*, (VA-0333903)
OBJECTIVE: Evaluate waste treatment systems, such as lagoons, as solar energy storage reservoirs. Evaluate types of solar collectors for heating lagoons, and develop and evaluate methods for recovery of heat from waste systems through use of heat pumps.
APPROACH: Solar collectors for heating fluids such as found in waste treatment lagoons, will be designed, and used to heat an existing lagoon. Heat pump systems for recovery of energy stored in the lagoon will be designed and used for space heating of a livestock shelter. Overall performance of the system will be evaluated by comparing performance with and without the solar energy input.
PROGRESS: A solar assisted heat pump system using a thermal storage pond was used to heat a swine nursery (2.4 m multiplied by 4.9 m multiplied by 2.4 m high) for raising pigs (three groups and 36 pigs/group) during Winter 77-78. Water, heated by solar panels (15.52 m (2)) was circulated through the inlet coils of a water-to-air heat pump to heat the building. An insulated, covered water pond, which could be inexpensively constructed by a farmer using available building materials and equipment, was used for storage of solar heat for use with the heat pump at night and during cloudy periods. System operation temperatures, electric power usage, and solar radiation were recorded during the tests. Pig health and growth were comparable to other housing methods using conventional heating systems. Measured COP values for the heat pump and overall system were 2.63 and 2.04, respectively. For a COP above 2, the operating cost for this solar assisted heat pump system is comparable to other conventional heating systems using fossil fuels and significantly better than electric resistance heating. Initial investment for the heat pump system is, of course, greater. Storage pond temperatures ranged from about 5 to 35 degrees C for ambient outside air temperatures down to minus 19 degrees C.
SUPPORTED BY: Virginia State Government.

1.0182
IMPROVED SYSTEMS FOR HARDWOOD LUMBER DRYING
Wengert EM, Skaar C, School of Agricultural & Life Sciences, Virginia Polytechnic Inst. & State University, *Blacksburg, Virginia, 24061*, (VA-0632323)
OBJECTIVE: Improve effciency of hardwood drying and reduce fossil fuel use by: Testing methods for improved control of lumber dry kilns. Evaluating solar, dehumidifying and high temperature dryers. Evaluating pre-treatment methods to prevent end splitting. Developing data for assessing cost of all alternatives in drying systems tested.
APPROACH: Test process control by acoustic emissions, electrical resistance, and direct measurement of weight loss in new experimental kiln just instlled at VPI. At site of industrial cooperator and at VPI end-coat tests and control with was emulsion and other materials prior to kiln drying. At site of industrial cooperator and at VPI evaluate solar predryer, dehumidifying, predryers, and high temperatures (100 degrees C and above). Cooperators will keep cost data on drying methods tested on industrial-size kilns.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0183
HOUSING FOR LOW- AND MODERATE INCOME FAMILIES
Hurst HT, Durrani TM, School of Architecture & Urban Studies, Virginia Polytechnic Inst. & State University, *Blacksburg, Virginia, 24061*, (VA-0622332)
OBJECTIVE: Provide innovative designs and research assistance for the construction of prototype housing systems and subsystems and for rehabilitation of existing housing and review and evaluate them by interdisciplinary teams. Determine societal constraints to the adoption of housing alternatives, including those of finance, cost, regulations, policies, land use and energy use. Determine constraints within the family to the adoption of housing alternatives including demographic characteristics, family resources, family decision-making processes and consumer acceptance. Develop effective methods of disseminating housing research information to consumers and key decision-makers in the area of housing.
APPROACH: Conduct evaluative studies to compare prototype houses with selected standard houses for design, material cost, equipment, and energy consumption. Design and administer consumer-responsive questionnaires. Conduct case studies on adoption of housing innovations, residential solar energy technology, and other alternatives by interviewing officials, experts producers, consumers, and financiers. Evaluate housing information networks, assist in preparation of housing workshop guidelines, and support state/regional workshops.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0184
WOODLAWN SOLAR GREENHOUSE
Lensch JE, Roanoke Independent Source of Energy, *Salem, Virginia, 24153*
PROGRESS: An attached solar greenhouse was constructed on the south facing side of a small private, non-profit grade school in Salem, VA. Excess heat will be blown into the school during the day. If school heat requirements are satisfied, the remaining heat will be ducted into a rock bin located under the greenhouse floor. This heat will radiate up through the concrete slab to temper temperatures at night. The school is currently heated electrically. The heat produced by the greenhouse is expected to reduce the electric consumption by 30 to 50%. The greenhouse is in the final stages of construction. Monitoring and data collection will take place this winter. The final analysis and report are to be completed in March 1981.
SUPPORTED BY: U.S. Dept. of Energy.

1.0185
SOLAR UTILIZATION ECONOMIC DEVELOPMENT AND EMPLOYMENT (SUEDE) EVALUATION PROJECT
Bentley R, Norm Hodges & Associates Inc., *Springifield, Virginia, 22150*
OBJECTIVE: The goal of the Solar Utilization Economic Development and Employment (SUEDE) project is to demonstrate the feasibility of combining solar heating technology, job training and small business development, all with the aim of promoting energy conservation and economic growth in disadvantaged communities. Federal funds allocated by the Department of Labor, Community Services Administration and the Department of Energy were used to develop and implement a series of pilot projects to demonstrate these objectives in low-income rural and urban communities. At each selected site CETA enrollees were trained in the basic skills to design, construct, install, and maintain certain types of solar hot water/space heating or related systems appropriate to the needs of low-income homes. Projects were directed to two basic models: (1) to assist minority private sector business development and employment opportunities; and (2) to serve as prototypes for subsidized public service job creation in the developing solar market. A telephone survey was conducted on all 15 sites which provided a method of selecting a smaller number 6 for more intense analysis. An indepth interim report has been submitted to DOE for approval on the telephone survey and the final report, which will include case studies on the 6 selected sites, will be completed by October 31,1980.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

1.0186
PROOF OF CONCEPT OF TWO NOVEL SOLAR HEATED GREENHOUSES
Straub DE, Zornig HF, Ecotope Group, *E. Seattle, Washington, 98112*, (7095-20691-014-A(1))
OBJECTIVE: Design, demonstrate, and evaluate the concept of low-cost passive solar heating of greenhouses for use in area of limited space or water utilizing passively controlled ventilation/cooling systems and integrated plant and aquaculture production

APPROACH: Construct and test a "parabolic" greenhouse with a floor area of 360 ft , reflective and insulated parabolic north wall, a 5000 gal pond of water for solar energy storage and a growth area for fish (talapia), and a thermal ventilation stack 20 ft high. Monitor the environmental and biological systems and compare theoretical and actual performance to specify equations describing transient behavior of the greenhouses. Use performance data to improve and optimize designs for passively heated and cooled greenhouses and maximizing greenhouse production.
PROGRESS: The parabolic/aquaculture greenhouse was restocked with fish after a fish kill. Various fish varieties, including Tilapia were stocked to form a polyculture. Tilapia doubled in size during a one month period. A thermal equilibrium computer model was tested by simulating performance under two conditions - full sun and cloudy spring days. The model predicted water temperature at a 2' depth within 1/2 degrees F and air temperature within 3 degrees F during the night. CO(2) is being added to the aquaculture greenhouse via two-compartment compost bins. Concentrations of CO(2) will be measured with a Draegar Scientific indicator tube supplemented with a gas chromatograph.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0187
PHYSIOLOGY AND CULTURE OF HIGH QUALITY HOPS
Unknown, Irrigation Agricultural Research & Extension Center,U.S. Dept. of Agriculture, Agricultural Research, *Prosser, Washington, 99350,* (5806-20010-002)
OBJECTIVE: Study physiology of the hop plant, develop improved production practices, and test hop varieties and selections for adaptation to irrigated hop producing areas.
APPROACH: Studies on gland and cone development will be conducted in greenhouse and field with virus-free and infected clones. Determinations of total soft resins, oil content and oxidation products will be made in laboratory with lupulin glands. Field studies will be carried out to develop improved cultural practices under a low trellis design. Domestic and foreign varieties and advanced selections from breeding programs will be evaluated for agronomic and chemical characteristics and disease and insect resistance to identify clones adapted for hop production under irrigation in the hot, dry interior valleys of the Pacific Northwest.
PROGRESS: Fifty-two advanced hop selections were submitted to five brewers for evaluation as aroma and extract types. Two aroma selections and one extract-type were selected by brewers for commercial testing. Three commercial varieties and one experimental selection had comparable yields on both 2.15 meter and conventional 5.54 meter trellis. Alpha-acid content was increased 10 to 50% in five hop varieties grown under a low trellis system with trickle irrigation, fertigation and no cultivation. Solar drying plus recirculation of kiln hot air reduced oil consumption by 10%. Baled fresh hops and semi-dried hops at 79% and 18% moisture, respectively, dried to 8% moisture with a vacuum microwave system retained their high quality. Microwave drying did not influence storagability.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0188
DIRECT PASTEURIZATION OF FRUIT JUICES USING SOLAR ENERGY
Davis DC, Berry RE, Dept. of Agricultural Engineering, Washington State University, *Pullman, Washington, 99163,* (7003-20510-019A-(1))
OBJECTIVE: Determine technical feasibility of using solar energy for direct pasteurization of fruit juices. Develop recommendations for designs of solar collectors suitable for fruit juice pasturization and determine effects of direct solar radiation exposure on product.
APPROACH: Survey commercial and experimental solar collector designs and select most feasible for direct food product pasteurization. Analyze available solar energy in Washington fruit processing regions and relate to energy needs for pasteurization. Measure minimum time-temperature parameters for safe pasteurization of fruit juices. Measure absortivities of different light wave lengths and test relative effects upon fruit juice sterilization and product quality (including color, nutrients and flavor).
PROGRESS: Several pasteurization time-temperature profiles have been studied for solar energy pasteurization of grape juice and apple juice. Thermal and solar radiation absorption properties of these juices are being evaluated. A mathematical model has been developed of the heat transfer processes for use in defining flow control procedures that will provide optimal thermal processing of the juice.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0189
UTILIZATION OF SOLAR ENERGY IN FOOD PROCESSING
Davis DC, Kranzler GA, Henry KL, Dept. of Agricultural Engineering, Washington State University, *Pullman, Washington, 99163,* (WNP00403)
OBJECTIVE: Characterize energy use of specific unit processes that are important to the food processing industry of Washington State. Characterize solar energy availability at representative locations that are important centers for food processing in the state. Determine the potential for solar energy use at specific processing sites and necessary energy storage capacities and adapt existing processes or develop new processes that can efficiently utilize solar energy for food processing. Determine minimum thermal processing requirements of foods while providing reasonable safety margins. Evaluate the safety, quality, and storage stability of food products processed with solar energy.
APPROACH: Published literature, personal communication, and field data collection will be used to obtain data for objectivess 1 and 2. Processing operations and solar radiation characteristics will be studied together to define appropriate solar collection and storage systems. Technical and economic factors will be evaluated for solar energy systems. Where process modification are needed to utilize solar energy efficiently, investigations into new or improved processes will be conducted. Equipment will be constructed and tested to evaluate these processes.
PROGRESS: Solar energy data for the state of Washington have been compiled and analyzed on daily, weekly, monthly and annual bases. Energy availability varies with location within the state, being greatest in the semi-arid regions of the state. The regions having greatest solar availability also support the most energy-intensive agriculture and contain most of the food processing facilities. Although greatest solar energy levels occur during July, levels exceed 50% of the July levels from March through October. Thus, much of the energy-intensive food processing industry of the state is located in regions of high solar availability and operates during months in which solar energy levels are high. Sixteen food processing plants have been surveyed and visited by engineers to determine the energy use patterns and process temperatures of major processing plant types in the state. The energy content of waste streams leaving processing plants was an energy resource identified that has great potential for conserving energy in food processing plants. Additional research is needed to couple waste energy with solar energy for maximum conservation.
SUPPORTED BY: Washington State University.

1.0190
SOLAR-ASSISTED DRYING OF HOPS
Kranzler GA, Butler JL, Dept. of Agricultural Engineering, Washington State University, *Pullman, Washington, 99163,* (7003-20190-015A(1))
OBJECTIVE: Investigate by field study the technical and economic feasibility of utilizing solar energy as a supplemental thermal source for the drying of hops by means of preheating ambient system intake air and conditioning kiln exhaust air for system recirculation.
APPROACH: A portion of the roof of an existing conventional design multi-kiln hop drier plant will be modified to serve as a solar collector. The collector design will permit preheating outside air or conditioning and recirculating kiln exhaust air. Both modes of operation will be evaluated and energy conserved will be determined by comparison with a second unmodified kiln.
PROGRESS: The roof of an existing multi-kiln hop drying plant was modified to function as a solar collector. Heated air from this collector is ducted to the fan intake to supplement furnace output. The collector design permits preheating of outside air or optional conditioning and recirculation of kiln exhaust air. Hop drying was begun on Augst 21 and completed on September 24. Long-term weather data show that the average number of cloudy days in August and September is 2 and 4 respectively. By contrast, only five sunny days occurred during the 1978 drying season. Further, the cloudy and rainy weather upset normal harvesting routines. Data were gathered and although complete analysis has not been made, they are expected to show energy savings due to the solar collector system.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0191
MAXIMIZING THE EFFECTIVENESS OF BEES AS POLLINATORS OF AGRICULTURAL CROPS
Johansen CA, Klostermeyer EC, Dept. of Entomology, Washington State University, *Pullman, Washington, 99163,* (WNP00257)
OBJECTIVE: Develop bee management techniques that increase the value of bees as pollinators. Determine conditions that protect bees from environmental hazards.
APPROACH: Nesting activities and behavior of alkali and leafcutter bees will be stressed. Cultural practices related to timing of alfalfa bloom will be stressed. Integrated control, stressing chemicals least harmful to predators will be emphasized. Chemicals, timing, and application methods least harmful to bees will be investigated. Biology and behavior of parasites, predators, and scavengers will be studied to learn how to minimize their damage. The effect of parasite, predator, and scavenger activities on bees will be quantified.
PROGRESS: Orchard pollination with the orchard manson bee was inhibited by cold, wet spring weather. As a result, low percentages (68%) of renesting occurred. It is not known whether this is due to normal dispersal of the bees from the original nest or to other conditions. To induce greater activity during cold weather, simple solar heaters were added to some shelters. This resulted in overheating, inducing bee activity when the air temperature was too low to sustain flight. However, the results suggest that a moderate nest temperature increase would be useful. Observations of the pollinating behavior of the bees on apples show they spent an average of 6.5 seconds per flower, 7.5 seconds per cluster, 15.9 seconds per branch, and 1 minute per tree. Based on the number of trips and the length of time to complete a cell, bees visit over 2,000flowers per completed cell. If each bee completes 8 cells during apple bloom, an adequate apple crop could be produced by 130 females per acre, but very likely 5 to 10 times that number would be required in commercial practice to compensate for poor weather, loss of bees, and other contingencies. The orchard mason bee remains a good prospect as a domesticated pollinator for fruit production but factors inhibiting maximum reproduction under orchard conditions must be overcome.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

1.0192
ECONOMIC ANALYSIS OF SOLAR ASSIST IN FOOD DEHYDRATION AND HOT WATER OPERATIONS
Lund DB, Berry RE, Dept. of Food Science, University of Wisconsin, *Madison, Wisconsin, 53706,* (7002-20510,018A-(1))
OBJECTIVE: Assess economic feasibility of solar-assist food processes. Determine theoretical energy demand model which would result in economically viable system. Recommend food drying operations which can result in systems more compatible with solar energy use.
APPROACH: Collect energy demand information from six dehydrated-food projects on the national DOE research program. Using transient simulations of solar supply, collection, and storage, identify dehydration process modification needed to improve efficient usage of solar energy in those processes. Recommend changes in direction of current on-going research projects and potential needed new projects for optimum use of solar energy in food dehydration.
PROGRESS: Transient simulations of solar energy supply, collection and storage were used to determine the compatibility of solar energy in meeting these demand loads. Feasibility for incorporating solar energy into food dehydration processes was assessed using F-CHART, an economic simulation program. Results identify economic conditions under which a solar assist becomes more economically feasible. The more important economic parameters are: cost of back-up fuel, annual rise in back-up fuel costs, annual market discount rate on dollars, term of mortgage, annual interest rate on mortgage and collector costs.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0193
IMPROVEMENTS IN DRYING TECHNOLOGY
Simpson WT, Forest Products Lab, U.S. Dept. of Agriculture, Forest Service, *Madison, Wisconsin, 53705,* (FPL-3214)
OBJECTIVE: Advance the level of technology of wood drying above the level available at present, and improve the performance and yield of wood products through improved drying practices.
APPROACH: Reduce the cost of drying hardwood lumber by optimizing and, where possible, integrating techniques such as high-temperature drying, segregation, pretreatments, kiln automation, and rapid, in-line drying of clear cuttings. Assess the effect of drying conditions on shrinkage and warp. Increase the level of control over the softwood drying process in order to reduce the variation in final moisture content after drying, and to quantify the effect of high-temperature drying on the strength of softwood dimension limber and develop minimum strength-reducing drying processes. Reduce the dependence on fossil fuels in wood drying processes by designing and building a solar lumber kiln and demonstrating its technical feasibility.
PROGRESS: An Agriculture Handbook on storage of lumber has been published. It outlines procedures to reduce lumber losses during storage. The continuation of research on the effects of bacterial infection on drying response of lumber has shown the California black oak often cannot be profitably kiln dried because of drying defects and reinforces the need to develop segregation techniques. A state-of-the-art paper that reviews current knowledge and points out research needs has been written on the processing problems associated with bacterially infected wood. Acoustic emissions given off by internal fractures during drying have been correlated with drying defects, and the instrumentation has been developed to detect these emmissions. The results lay the groundwork for development of a possible process control system. The basic drying rate of northern red oak lumber has been correlated with thickness, temperature, and relative humidity so that it is possible to estimate drying time at any combination of these variables. This type of engineering data on drying rate does not exist for commercial species, and if this result proves useful, it could establish the need for similar data on other species. Development of more time and energy efficient high temperature drying process for hardwoods continues with investigations on additional species.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

1.0194
COMMUNITY SOLAR DEMONSTRATION/DISSEMINATION CENTER
Martens LC, Tepp D, Environmental Dept., Seymour Community Schools, *Seymour, Wisconsin, 54165,* (40.810.540.500000.500.1)
OBJECTIVE: The objective of this project is to add a passive/active solar heating demonstration component to an orientation building to provide a seminar center for students and community people.
APPROACH: The center will provide solar demonstration/dissemination materials and activities for schools and the public. The objectives will be accomplished by incorporating a 9 x 10 double glazed greenhouse system into an orientation building at Fallen Timbers Environmental Center to achieve passive heating and storage in a Trombe wall. In addition, a direct gain air collector will also be built and integrated into the building by students. A Queen Aire fireplace will be used as the backup system for the passive concepts. The expected outcome is a solar demonstration/dissemination center managed by a consortium of schools designed to provide information and actual demonstration of solar heating.
SUPPORTED BY: U.S. Dept. of Energy.

1.0195
SOLAR HEAT SYSTEM FOR WYOMING RURAL ELECTRIC ASSOCIATION
Unknown, Wyoming Rural Electric Assn., *Casper, Wyoming, 82601*
Summary information has not been provided.
SUPPORTED BY: U.S. Dept. of Energy.

1.0196
DRYING AND STORING OF RICE AND WHEAT
Sabbah MA, Lai FS, Gameat Al Iskandaria, *Alexandria, Egypt,* (8005-20590-001)
OBJECTIVE: Determine characteristic drying rates and moisture equilibria for rice grown in Egypt. Establish requirements for drying rice with natural air and with solar heat. Develop indices for measuring rice deterioration.
APPROACH: Using standard techniques, measure the characteristic drying rate and equilibrium moisture content of rice fully exposed to air of selected temperatures and relative humidities. Measure direct and diffuse solar radiation and explore its application for drying rice. Develop deterioration indices based on temperature-moisture-time relationships and dry matter losses for use in evaluating in-storage drying procedures.
PROGRESS: Studies included existing methods of storage in Egypt, bulk-storage in silos with and without aeration, measurement of the physical properties of paddy rice, determination of drying characteristics of paddy rice, and testing the feasibility of using solar energy for drying paddy rice. In addition, the action of insects, mites and fungi, and the development of fat acidity were measured. The initial moisture content of paddy rice stored in different commercial warehouses ranged between 20 and 28%(d.b.). The moisture content decreased slightly with time but remained too high for safe storage with an average value of 18% (d.b.). The moisture content-time relationships in the three warehouses were similar. Fungal activities increased substantially as storage time elapsed. The initial degree of infection in all sample swas 3 + 0.2%, but increased in 12 weeks to 7.8-8.5% when the rice was stored in the open. For rice stored in a closed shelter and in a shed, the degree of infection increased in 12 weeks to 6.0 and 6.8%, respectively. The degree of infection by insects and mites in stored rice was in most cases small and never exceeded 7 insects per 100 gm, and 6 mites per 100 gm of grain. Fat acidity fluctuated around a mean value of 20 mg KOH per 100 gm of rice. Aerating bulk grain with a 0.4 m 3/min of air per cubic meter of grain decreased the average moisture content from 21% (w.b.) to 13.5% (w.b.); degree of infection was negligible.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0197
UTILIZATION OF SOLAR ENERGY AND THE DEVELOPMENT OF AN EGYPTIAN VILLAGE IN AN INTEGRATED FIELD PROJECT
Arafa S, American University in Cairo, *Cairo, Egypt,* (INT78-01127)
OBJECTIVE: In a collaborative research project between Drs. Salah Arafa and Cynthia Nelson of the American University in Cairo and Dr. Edward Lumsdaine of the New Mexico State University, a study will be made of the social impact upon an Egyptian village of the introduction of solar technology.
APPROACH: The village, which has neither electricity nor an acceptable water supply, is already favorably disposed to the change. Both "low" technologies, such as water heaters and ovens, and "high" technology, such as electricity generation, will be selected and applied to food preparation, water purification, water pumping, and biomass conversion. The effectiveness of the new technologies in fulfilling the villagers' needs as well as fitting into their social structure will be evaluated. Attempts will be made to generalize the experience for application to similar rural communities. The problem of the impact of technology on life style is prevalent at all socio-economic levels in almost all countries of the world. Low technology, isolated rural villages are particularly prone to social disruption as technology is introduced into the village life. This is true in Egypt and other LDC's, as well as in parts of Southwestern U.S. This award supports the costs of the project at the American University in Cairo, while a companion award, INT78-01126, supports the costs at the New Mexico State University.
SUPPORTED BY: U.S. National Science Foundation.

1.0198
A COORDINATED RESEARCH PROGRAM ON OPERATIONAL RESEARCH IN SOLAR ENERGY UTILIZATION IN AGRICULTURE
Garg HP, Butler JL, Altman LB, Central Arid Zone Research Inst., *Jodhpur, India,* (8001-2190-142)
OBJECTIVE: To investigate the utilization of solar energy for drying crops, producing potable water, and providing supplemental heat for increasing the production of biomass.
APPROACH: Design criteria will be developed for solar crop dryers, solar stills and solar cookers. Hardware will then be assembled and the units tested to determine the technical and economic feasibility. The dryers will be used on crops such as maize, rice, peanuts, mustard seed and vegetable crops. The solar stills will be evaluated for the production of potable domestic water from saline water and water which is otherwise unfit for drinking purposes. Solar cookers will be evaluated for their potential in reducing other energy inputs in the cooking of food. Solar energy will be applied to gobar gas plants in the winter and the production of this unit will be compared with that of similar plants without the solar assist. This research will be conducted at five separate locations in India.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

1.0199
SOLAR COLLECTORS INTENDED FOR INSTALLATION IN GREENHOUSES (P324)
Henriksson R, Swedish University of Agricultural Sciences, *Lund, Sweden, S22006 Lund 6,* (79-5996)
OBJECTIVES: To study and develop solar collectors intended for installation in greenhouses. The objectives are to clarify the advantages of using the solar collectors and to investigate specific requirements related to optimum adjustment to important parameters in an integrated system. The project will result in general recommendations and directions for the designing and usage of solar collectors for indoor cultivation.
APPRACH: A properly functioning indoor solar collector should be transparent to permit passage of radiation in the wavelength range 400-750 nm, i.e., the kind of radiation which is used in the photosynthesis by plants. The solar collector material should be flexible to enable it to be pulled aside during periods when the plants require a great deal of light. The dimensions of the solar collector and the flow quantity and temperature of the heat

transfer medium should be adjusted to the heat requirement and energy storage potential of the greenhouse. The efficiency of the solar collector under various conditions will be determined through measurements and data analyses involving important parameters in the integrated system.
PROGRESS: Studies have been made of the spectral properties of various materials and of the heat transfer medium. Practical designing and construction of an indoor solar collector intended for installation in greenhouses.
SUPPORTED BY: Styrelsen for Teknisk Utveckling.

1.0200
OPTICAL PROPERTIES OF SURFACE COATINGS - FUNDAMENTAL RESEARCH IN ENERGY
Granqvist CG, Dept. of Physics, Chalmers Tekniska Hogskola, *Goteborg, Sweden, S40220 Goteborg 5*, (80-3107)
OBJECTIVE: To develop surface coatings suitable for the effective use of renewable sources of energy including: a) Surface coatings for flat plate and focusing solar collectors b) Surfaces for passive colling down to low temperatures c) Surface coatings reducing thermal losses through windoes and in light bulbs.
APPROACH: Studies of the three types of surface coatings. 1) Spectroscopically selective surfaces for the photothermal conversion of solar energy will be developed by co-deposition of the metal and the insulator, with the object of producing a granular film on the metal substrate. Theories with regard to the optical properties of surfaces thus formed will be put forward and work aimed at finding suitable measurement methods is in progress. 2) Surfaces for radiation cooling down to low temperatures have been produced by vapor deposition of certain oxides on reflecting metal sheets resulting in strong emission in the "atmospheric window", at 8 to 13 microns. A new method for determining optical constants for this kind of surface coating has been developed. 3) Transparent heat mirrors, i.e., surfaces reflecting thermal infra-red radiation but letting through visible light, are being the subject of research using very thin films of free-electron metals and certain doped semiconductors.
PROGRESS: The project is well under way and currently accounted for in foreign reviews and at international conferences.
SUPPORTED BY: Styrelsen for Teknisk Utveckling

2. WIND ENERGY

2.0001
MESOSCALE WIND PATTERN ANALYSIS AND MODELLING
Wagner KK, Dept. of Land, Air & Water Resources, University of California, *Davis, California, 95616*, (CA-D#-LAW-3463-H)
OBJECTIVE: Develop an objective numerical method to analyze mesoscale wind patterns in the Central Valley and adjacent areas. With this analysis method, historical wind data will be analyzed to construct mesoclimatic wind patterns. The feasibility of extrapolating mesoclimatic wind patterns from the current climatic data will be determined.
APPROACH: The wind pattern analysis will be a numerical variational analysis, a technique which combines observational data with a model of atmospheric structure. The atmospheric model will extend the analysis to regions not covered by observations. The analyses of wind data from the Central Valley will be averaged to produce a mesoclimatology of wind. A comparison of these wind patterns with those derived from analyses of climatic averages will determine the feasibility of extrapolating the mesoclimatology from the currently available climatology.
PROGRESS: A study of the variation of grid resolution in a surface wind flow model found that a two kilometer grid size was needed in the model when using the model in the Lake Tahoe region. The model was more successful in accounting for terrain effects on the wind flow than it was in simulating thermal effects. The region of study of wind flows within complex terrain is being moved to the geothermal energy area in Northern California. Comparisons of model output and measurements are planned.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0002
WINDMILL-POWERED HEAT PUMP IN A DAIRY OPERATION
Meroney RN, Klueter HH, Dept. of Civil Engineering, Colorado State University, *Fort Collins, Colorado, 80523*, (1090-20401-004-A(1))
OBJECTIVE: Gain more needed experience from operating a windmill system, and determine the technical and economical feasibility of a windmill-driven heat pump for a dairy operation.
APPROACH: A vertical-axis windmill has been constructed and connected electrically to the milk cooling-water heating system at the Colorado State University dairy farm. It has been instrumented and some data has been taken. Data will be continuously taken during the agreement and will be summarized and included in a report at the end of the project.
PROGRESS: This CRIS is a continuation of CRIS Work Unit No. 1090-20401-003C with Kaman Sciences Corporation in which a vertical-axis wind turbine (VAWT) was installed on a dairy farm to generate 60 Hz electricity in parallel with the utility power. This drives a refrigeration compressor to cool milk and heat water. Some modifications from previous recommendations were made on the system and data continues to be taken on the performance and efficiency of the system.
SUPPORTED BY: U.S. Dept of Agriculture, Agricultural Research.

2.0003
HEATING OF RURAL STRUCTURES WITH WIND-DERIVED ENERGY
Soderholm LH, U.S. Dept. of Agriculture Soil & Water Res. Conserv. Div., Iowa State University, *Ames, Iowa, 50010*, (3408-20690-002)
OBJECTIVE: Development of heating systems for rural structures using wind energy to reduce consumption of nonrenewable energy resources for heating, to provide standby heating in case of failure of other heating sources, assist in reducing electrical peak demand, and provide load leveling for heating systems using electricity as an energy source.
APPROACH: Install wind generating systems, controls, and heat storage for supplementary heating of farm structures in combination with heat pumps or other primary energy sources. Determine both theoretical and derived power from experimental wind systems and optimize wind system and storage concepts to obtain maximum heating systems efficiency and costs effectiveness.
PROGRESS: The Gruman Windstream 25 was inoperative during the entire period of 1979 from February to December. A shutdown was requested by Gruman because of a safety hazard with the blades. The extended time was required for shipment and repair of the unit at the factory. The Cornell contract on heating water by mechanical agitation was monitored and very satisfactory progress made. A contract for the Economic Analysis of Wind-powered Farmhouse and Farm Building Heating has been established with Regional Systems Services Group and preliminary analyses are proceeding on schedule. An analog cubing circuit has been designed and constructed for obtaining the average of the cube of anemometer outputs. Data on wind power availability as determined by the cube of the average wind velocity have been shown to substantially underestimate the true power in the wind as determined by the average of the cubes.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0004
WIND ENERGY FOR PUMPING IRRIGATION WATER
Hagen LJ, Skidmore EL, Lyles L, U.S. Dept. of Agriculture, Agricultural Research, Kansas State University, *Manhattan, Kansas, 66504*, (3420-20740-001)
OBJECTIVE: Determine the seasonal wind energy distribution in the Great Plains and develop strategies to utilize wind energy for pumping irrigation water.
APPROACH: Analyze climatological data to determine seasonal wind energy distribution over the Great Plains. Develop a computer simulation model to explore strategies to satisfy irrigated crop water requirements using wind energy considering several energy storage possibilities and using realistic constraints on irrigation wells, pumps, and wind turbines.
PROGRESS: A prototype vertical-axis wind turbine system in Western Kansas was used to pump water from a tailwater pit into a small elevated storage reservoir. Gated pipe was used to irrigate 1.5 ha of grain sorghum from the reservoir. The irrigation system performed satisfactorily, but automated valves on one or two sets of gated pipe would be necessary to minimize storage reservoir capacity. Long-term relationships among monthly runoff volume, runoff pumped, wind turbine pumping capacity, and pit storage capacity in Western Kansas were developed using a computer simulation model of a wind-powered tailwater system. Results show which combinations of wind turbine size and pit capacity could be used to pump a given runoff volume.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0005
WIND ENERGY POTENTIAL FOR AGRICULTURAL APPLICATIONS IN LOUISIANA
Baldwin JD, Verma LR, Dept. of Agricultural Engineering, Louisiana State University, *Baton Rouge, Louisiana, 70803*, (LAB02091)
OBJECTIVE: To evaluate available wind speed data for suitability in estimating wind energy potential and to evaluate the potential use of wind energy in Louisiana for agricultural applications.
APPROACH: Instruments for measuring and recording wind speed data at high sampling rates will be installed at Ryan Airport, Baton Rouge, Louisiana. Root-mean-cube velocity values will be determined for comparison with data obtained by the National Weather Service. These data together with data from several other NWS-reporting stations in Louisiana will be analyzed to evaluate the intensity and variation in wind energy potential in Louisiana.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0006
FUNDING AND TEST APPLICATIONS FOR THE PRODUCTION AND UTILIZATION OF WIND GENERATED ENERGY IN RURAL AND AGRICULTURAL APPLICATIONS
Altman B, U.S. Agricultural Research Center, Dept. of Agriculture, *New Orleans, Louisiana, 70153*, (EX-76-A-29-1026)
Summary information has not been provided.
SUPPORTED BY: U.S. Dept. of Energy.

2.0007
DEVELOPMENT OF WIND POWERED EQUIPMENT FOR AGRICULTURE
Liljedahl LA, Klueter HH, Agricultural Environmental Quality Inst., U.S. Dept. of Agriculture, Agricultural Research, *Beltsville, Maryland, 20705*, (1109-20400-001)
OBJECTIVE: Develop economical equipment to utilize wind power to cool milk and heat water on a dairy farm.
APPROACH: A windmill will be designed and built to provide power to several requirements at a dairy farm. Tests will be conducted to determine its suitability for this application, the operating characteristics of the system, local wind characteristics, and accuracy of design assumptions. Modifications will be made to improve performance or reduce cost as needed.
PROGRESS: Vibration analysis of 60-foot free-standing tower for wind turbine was completed. Modes are well separated from driving frequencies of turbine rotor. Computer simulation was made fr several combinations of compressors for optimum use of energy generated by the turbine. Continued analyses will be made. No progress on the construction of wind system. Awaiting approval by DOE to proceed. A report summarizing analysis and simulation work being prepared.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0008
WOOD COMPONENTS FOR WIND ENERGY SYSTEMS
Hoadley RB, Agricultural Experiment Station, University of Massachusetts, *Amherst, Massachusetts, 01002,* (MAS00023)
OBJECTIVE: Develop construction details and fabrication procedures for machine blades in wind energy systems. Develop use of wood support tower structural systems for wind power generators.
APPROACH: Engineering requirements of stress capabilities and weight distributuon to be determined by Civil Engineering Department. Wood technologists to select wood species and develop fabrication procedures. Civil Engineers will test wood propeller blades on wind power electricity generators.
PROGRESS: Using a modified design employing spruce spars, maple plywood skins and urethane foam filling, a functional set of blades for a 16.4-foot diameter propeller was constructed. Three of the blades have been installed on the University's 6 kw Elektro machine and are being monitored for overall performance. A fourth matched blade, loaded staticly to failure, carried approximately triple the calculated survival wind load. Failure occurred in the metal attachment hardware. A simple machining jig was constructed which enables rapid preliminary carving of spars to prescribed taper and twist, demonstrating the potential of economical production of contoured spar designs. Design work has been completed for a prototype blade for 35-foot diameter propellers and a scale model has been assembled. Trial full-scale blade sections are now being constructed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0009
INTERCONNECTING A 25 TO 40 KW WIND TURBINE ON A FARM TO A UTILITY
Amon DM, Amon Cherrywood Farms, *Williamsburg, Michigan, 49690*
OBJECTIVE: The objective of the project is to demonstrate commercial feasibility and adaptability of wind power on farms.
APPROACH: A 25 to 40 KW induction generator wind turbine will be installed to generate electricity for farm use and the excess power will be sold back to the utility.
SPONSORED BY: U.S. Dept. of Energy.

2.0010
UTILIZATION OF THE CLIMATIC RESOURCE
Decker WL, Dept. of Atmospheric Science, University of Missouri, *Columbia, Missouri, 65201,* (MO-00311)
OBJECTIVE: Examine the energy use of crop canopies in terms of photosynthetic and water efficiencies, develop workable mathematical expressions for predicting yield of important crops from weather data, and describe the climate of the state in terms of probability of climatic events favorable for Missouri's agriculture.
APPROACH: The effect of canopy design on utilization of sunlight and evapotranspiration by soybeans will be studied along with the influence of atmospheric conditions. The prediction of yields for soybeans and other Missouri crops will be attempted from statistical models. Existing regression methods will be refined to increase their precision. An analysis of availability of solar energy and atmospheric radiation will be completed. Wind power as a resource will also be examined. Additional analyses to isolate management strategies most suitable to Missouri's climate will be made.
PROGRESS: The climatic limitation to soybean production has been subjected to continued evaluation. The impact of varying cultural practices on moisture stress for soybeans has been analyzed under Missouri's climatic conditions. Higher moisture stress, as measured by plant-water potentials, occurred with soybeans planted in May than for June planting. Post emergence herbicides reduced the stress in soybeans because of the reduction in weed populations. Soybeans grown under no tillage experienced lower stress, but this was due to lower plant populations associated with this treatment. An analysis, which accounted for the plant population differences, showed a correlation between stress and soybean yields. This relationship indicates that management practices which minimize stress should be associated with increase yield in soybeans. A sampling technique has been designed to study soybean development as related to weather variations. Using soybeans planted on three different dates, the stages of development for each planting have been documented. Concurrent meteorological data were recorded. As part of the study of impact of climate on food production, a model for predicting rice yields from climatic variations is being developed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0011
NITROGEN FIXATION WITH WIND ENERGY
Martin CW, Fischbach PE, University of Nebraska, *Lincoln, Nebraska, 68503,* (NEB-11-058)
OBJECTIVE: Determine the feasibility of driving an electric arc reactor with the fluctuating power output of a wind turbine, producing nitrogen fertilizer. Use the varying load of one or several arc reactors as part of the speed control system of the wind turbine, thus reducing cost of the turbine system.
APPROACH: Review literature on electric arc devices such as nitrogen arc-reactors, plasma-arc heaters, and arc welders. Dimensional analysis and design of experiments. Measurements of electrical load characteristics of nitrogen arc-reactor and fitting functions to data. Computer simulation of wind turbine/arc-reactor systems. Identification of optimum configurations and operating conditions.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0012
ECONOMIC ANALYSIS OF WIND ENERGY FOR IRRIGATION PUMPING
Lansford RR, Clark RN, Southwest Research & Development Co., *Las Cruces, New Mexico, 88001,* (7011-20740-006-C)
OBJECTIVE: Assess the economic feasibility of utilizing wind power as a source of energy for pumping irrigation water by providing estimates of: number or irrigation pumping plants used in the United States; the investment in wind power system which would break even with present power sources and cost; and the number of potential wind powered irrigation pumping plants by region for alternative prices of present energy.
APPROACH: Irrigation pumping installations will be grouped by size, water source, and present energy sources for each area having similar average windspeeds. The annual costs of energy with present evergy sources will be calculated for pumping operations of different size and average annuals hours of operation using different levels of energy prices. The investment in wind power systems which will break even with the present power sources will be calculated for pumping operations of different size and average annual hours of operation using different levels of energy process. The investment in wind power systems which will break even with the present power sources will be estimated for each level of energy costs used and by wind power regions and irrigation load categories. From the data, the number of potential wind powered irrigation pumping plants by region will be estimated for alternative prices of present energy sources.
PROGRESS: The first phase of this study reports the number of on-farm irrigation pumping installations in the United States. Irrigation pumps were grouped by size, water source, and present energy sources for each state and each area having similar average windspeeds within states. Considerable difficulty was experienced in collecting irrigation pumping plant size information for several states. Almost 500,000on-farm irrigation pumps were found in all areas with 36% of them in good to excellent wind regions.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0013
ENRICHMENT OF A BRACKISH WATER POND FOR SHELLFISH CULTURE
Matthiessen GC, Ocean Pond Corp, *Fishers Island, New York, 06390,* (DAR80-09292)
OBJECTIVE: A major constraint upon the culture of edible marine organisms on a commercial scale in most coastal states is the lack of availability of suitable culture areas. Many ecologically favorable areas of the coastline are closed to aquaculture as a result of zoning restriction, local ordinances, and social resistance. As a result, the only recourse for many aquaculture enterprises may be to develop highly intensive culture techniques in areas of limited size. Ocean Pond Corporation has initiated experiments in the enrichment of a brackish water pond for the purpose of increasing the yield of Americal oysters (Crassostrea virginica). Preliminary small-scale experiments have indicated that the standing crop of phytoplankton, the primary source of oyster nutrition in the surface layers of the pond, may be increased by two orders of magnitude when enriched with bottom water. An artificial upwelling system to bring bottom water to the surface, will be installed by means of a wind-driven circulator, activated by a windmill. The objective is to determine if a significantly large area of the pond will show increased primary productivity, with significant benefits in terms of oyster growth rates and annual yields.
SUPPORTED BY: U.S. National Science Foundation.

2.0014
WIND ENERGY SUBSTITUTION AT DAIRY MILKING CENTER
Gunkel WW, Furry RB, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123335)
OBJECTIVE: Construct a wind turbine at the Cornell Dairy Research Farm using a commercially available unit. Design and construct a system to provide direct water heating through churning action in an enclosed container. Collect wind speed data at the site. Collect data to measure the effectiveness of the wind turbine conversion system.
APPROACH: The researchers will cooperate with a commercial wind turbine manufacturer to erect a wind turbine with blade or propeller diameter of approximately 32 feet. Engineering analysis will be conducted to design the blades to be used in the liquid churn to match the output of the wind turbine for optimum operation. The churn will be constructed and a full scale pilot demonstration system will be developed and tested.
PROGRESS: The wind turbine - hot water system at the Cornell Teaching and Research Center has been completely instrumented and a data acquisition system installed. Two new anemometer towers have been erected to replace the older storm damaged poles. System performance is being monitored continuously and data is automatically recorded on tape cassettes. Information recorded includes wind velocity and direction, wind turbine speed and shaft torque, and water temperature. Cassette data is collected daily and appropriate summaries compiled using the Minc II System. An economic analysis of the wind system has been completed and sensitivity analysis concluded. Additional dynamic responses of the water heater energy converter unit has been conducted and a study developed to provide a better dynamic power match between the wind turbine and the energy.
SUPPORTED BY: New York State Government.

2.0015
ENERGY CLIMATE OF NEW YORK STATE
Dethier BE, Dept. of Agronomy, Cornell University, *Ithaca, New York, 14850,* (NYC-125434)
OBJECTIVE: Describe and quantify the energy climate of New York State. Establish a data base for future interdisciplinary studies at the Center.
APPROACH: Solar radiation and wind direction and velocity at 10 meters will be observed and recorded at several sites (Harford, Ithaca, Mt. Pleasant, Aurora, Canton, Chazy and Valatie). These data will be used with data from other stations (Geneva, New York City, etc.) to obtain probability of occurrence of events meaningful to agriculture and other energy related activities. This information will be useful in characterizing energy consumption and in assessing the potential for extracting energy from wind for utilizing solar energy. Final results will be presented in map and tabular form for presentation in suitable station publications. The data will also be included in the monthly

weather summaries currently published by the unit.
PROGRESS: Development work is continuing on an improved electronic integrator for the radiation sensors. Radiation and wind data for selected stations have been put on magnetic tape for future analysis.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0016
EVALUATION OF THE PERFORMANCE OF WIND TURBINE CONCEPTS AND OPERATING WIND TURBINES
Keith TG, Dept. of Electrical Engineering, University of Toledo, *Toledo, Ohio, 43606*, (NCC 3-5)
Summary information has not been provided.
SUPPORTED BY: U.S. National Aeronautics & Space Admin.

2.0017
FEASIBILITY STUDY OF WIND GENERATED ELECTRICITY FOR RURAL APPLICATION
Kohring GW, Performing Institution Not Reported.
OBJECTIVE: The objectives of the project are: (1) to determine the ability to produce useful amounts of wind generated electricity in the south-western Ohio region; (2) to decide whether there is sufficient economic justification in producing domestic wind generated electricity; and (3) to determine the potential of wind generated electricity for reducing dependence on non-renewable energy resources in the south-western Ohio region.
APPROACH: A windmill will be erected and the power produced will be recorded. The power used directly from the generator and total power consumed on the farm will be compared. A cost effectiveness study will compare the total cost of purchasing, constructing, operating, and maintaining the generating system with the total savings incurred.
SUPPORTED BY: U.S. Dept. of Energy.

2.0018
WIND ENERGY FOR AGRICULTURAL APPLICATIONS
Hellickson MA, Young HG, Dept. of Agricultural Engineering, South Dakota State University, *Brookings, South Dakota, 57006*, (SD00796)
OBJECTIVE: Calculate the wind energy available at selected sites in South Dakota. Study the intensity and variation in this energy on a daily and monthly basis. Study the relative potential of wind energy as compared to other alternate energy sources. Evaluate the combined potential of wind and solar energies at selected sites in South Dakota. Investigate the potential of wind energy for agricultural applications.
APPROACH: The main thrust will be toward the feasibility of wind energy use for agricultural application, such as, crop drying, grain drying, and space heating. Existing climatological data at various locations in South Dakota. will be evaluated for wind energy potential; including wind variation studies. Some specific analysis will be made on the availability of wind power from data. The total wind energy flux passing unit area for each month of the year, average daily wind energy flux, the distribution in time of the available wind energy, number of hours per month with wind speeds adequate for effective wind energy conversion, details about the incidence and duration of calm periods. Results obtained are to be used in combination with available solar energy information to evaluate the combined potential of wind and solar energies in South Dakota.
PROGRESS: Analyses of eleven years of wind data for Huron, South Dakota reveal that April has the highest average wind speed, 13.3 mph, July the lowest, 10.3 mph, and the annual average is 11.5 mph. Daily wind power is maximum at about 1600 h and averages 210 w/m (2.) For Huron wind power levels up to 100 w/m (2) can be expected 95% of the time, 200 w/m (2) for 50% of the time and 300 w/m (2) for 13% of the time. Combining wind and solar energies significantly improves the energy density flux of these alternate energies. Preliminary design of a vertical axis wind turbine system to serve as the prime mover for a variable speed heat pump has been nearly completed. An unguyed, three bladed Darrieus system with Savonius rotors for starting is the wind turbine system being used.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0019
CHARACTERIZATION OF CLIMATE AND ASSESSMENT OF ITS IMPACT ON AGRICULTURE AND OTHER RENEWABLE RESOURCES
Lytle WF, Dept. of Agricultural Engineering, South Dakota State University, *Brookings, South Dakota, 57006*, (SD00565)
OBJECTIVE: Utilize available data sources to characterize the time and space distribution of climatic parameters that relate to agriculture production. Extend and improve the climatic and environmental data base, which will contribute to increasing the efficiency of agricultural production. Organize project results and information into forms readily available to users. To implement the research aspects of the National Climate Program that pertains to agriculture and renewable resources.
APPROACH: Determine climatic parameters that effect agricultural production by means of crop-climate models and probable occurence of unfavorable climatic conditions. Obtain more data on soil temperature, soil moisture, solar radiation, humidity, and wind velocity. Publish more individual station climatic summaries. Publish soil temperatures, soil moisture evaporation, humidity analyses, rainfall, wind energy, and solar radiation probabilities. Complete a state climate plan that will be approved by the Governor as indicated in the National Climate Program Act.
PROGRESS: Worked on a computer program to use data from Ashville, N.C. that would analyze velocity and wind energy probabilities from collected hourly data. 2) Worked with State Energy Policy office and U.S. Department of Energy representatives to furnish wind velocity and wind energy for wind turbine sites in South Dakota. 3) Worked with AGNET system to furnish climatic data for South Dakota as needed for present programs and develop new programs for crop-climate models in the state that would be useful for farmers and ranchers in comparing stages of crop development over different years.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0020
WIND ENERGY FOR LOW HEAD IRRIGATION
Wiersma J, Dept. of Agricultural Engineering, South Dakota State University, *Brookings, South Dakota, 57006*, (B-0062-SDAK)
Summary information has not been provided.
SUPPORTED BY: U.S. Dept. of the Interior, Office of Water Research & Technology.

2.0021
EVALUATION OF A WIND-WHEEL ELECTRIC-POWER GENERATOR
Swim WB, Dept. of Mechanical Engineering, Tennessee Technological University, *Cookeville, Tennessee, 38501*, (NAG 8-7)
Summary information has not been provided.
SUPPORTED BY: U.S. National Aeronautics & Space Admin.

2.0022
UTILIZATION OF WIND ENERGY FOR PUMPING IRRIGATION WATER FROM WELLS
Clark RN, Conservation & Production Research, U.S. Dept. of Agriculture, Agricultural Research, *Bushland, Texas, 79012*, (7315-20741-002)
OBJECTIVE: Evaluate the performance of wind turbines for powering irrigation pumps. Develop and test a wind-assisted diesel pumping system for irrigation. Evaluate and test various types of pumps for use with large wind turbines and determine economic feasibility of wind power irrigation pumping systems.
APPROACH: A vertical-axis, mechanical drive wind turbine will be installed at an existing irrigation well. The output from the wind turbine will be connected to a combination gear drive to assist the conventional diesel powered pump. Power measurements will be made to determine the efficiency of the wind-assisted pumping system. Other wind turbines will be tested when available. Cost comparisons will be made with pumping an equal amount of water by present energy sources. Performance of positive displacement pumps will be compared to a turbine pump when operated directly by a wind turbine.
PROGRESS: A conventional deep-well irrigation pump was powered by both an electric motor and a vertical-axis wind turbine. The wind turbine was coupled to the pumping system through an overrunning clutch and furnished power to the pump when the windspeed exceeded 6 m/s. This wind-assisted pumping system was chosen because it allowed water to be pumped at the desired flowrate regardless of the wind power level. The 40-kW wind turbine was operated at rotational speeds of 68, 81, and 90 rpm. Peak power produced by the turbine was 21 kW at 68 rpm; 31 kW at 81 rpm; and 52 kW at 90 rpm. Predicted annual power from 11 years of wind data show 63,800kWh for 68 rpm; 65,300kWh for 90 rpm; and 65,800kWh for 81 rpm. Even though peak power is highly dependent on rotational speed, little difference was found in annual power production.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0023
DEVELOPMENT OF ON-FARM WIND ENERGY SYSTEMS FOR IRRIGATION
Clark RN, Conservation & Prod Res., U.S. Dept. of Agriculture, Agricultural Research, *Bushland, Texas, 79012*, (7315,20745-001)
OBJECTIVE: Develop a stand-alone electrical pumping system for lakes and reuse systems. Examine a mechanical-drive wind power pumping system and develop other wind energy applications for the on-farm production of energy.
APPROACH: Large wind turbine systems will be coupled with irrigation pumps and field tested to determine water pumped, petroleum energy saved, and economics of wind systems. Load matching, management, and maintenance problems will be determined for each system tested. Emphasis will be placed on systems that operate independently of electric utilities and petroleum suppliers.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0024
PERFORMANCE OF WIND ROTORS USED FOR IRRIGATION PUMPING
Nelson VC, Clark RN, Dept. of Mathematics & Physics, West Texas State University, *Canyon, Texas, 79015*, (7091-20740-003-A(3))
OBJECTIVE: Determine the performance of a wind rotor for driving an irrigation pump; develop a computer model of a vertical axis wind rotor; determine economic feasibility of wind powered irrigation pumping systems.
APPROACH: The wind energy input to, and the power output from, a vertical axis wind rotor will be used to evaluate wind rotors for pumping irrigation water from wells. Wind speed measured as a function of time and height above the ground surface will provide the energy into the system. The shaft speed and torque will be measured to determine the output from the wind energy conversion system. A computer simulation model for a vertical axis wind rotor will be implemented and used to determine the optimum operating conditions for varying wind energy parameters. The wind rotor data will be used with irrigation pumping data from a cooperative study to determine the economic feasibility of wind powered irrigation in comparison to present energy sources.
PROGRESS: The performance of a 40-kW, vertical-axis wind turbine used in a wind assist pumping system was compared to a theoretical simulation model developed by the Department of Energy. The wind turbine produced less power than predicted up to a windspeed of 13 m/s. However, the turbine produced more power than predicted above 15 m/s. The difference between actual measured power and predicted power was about 20%. The theoretical model assumes the rotor blades are smooth with no connection on struts; both of which are present in the test turbine. The drag forces caused by the struts and blade connections apparently cause the poorer performance of this wind turbine. The average peak coefficient of performance was calculated as 0.29 and measured power output

showed the wind turbine converted 19% of the theoretical power in the wind to usable power. The annual energy output was estimated at 65,800kWh based on monthly wind histograms averaged over 11 years of Amarillo National Weather Service data. The energy produced during a typical 8-month irrigation season was 44,560kWh.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0025
ECONOMIC ANALYSIS OF WIND-POWERED CROP DRYING AND REFRIGERATION COOLING/WATER HEATING SYSTEMS
Forste RH, Klueter HH, Tetra Tech Inc., *Arlington, Virginia, 22209,* (1090-20401-005-C)
OBJECTIVE: Determine the economical potential for use of wind energy systems in crop drying and refrigeration cooling/water heating systems.
APPROACH: The study will be conducted by determining the number, size, and type of present operations; classify operations by category of present power source, power requirements, type of operation, season of operation, and geographical region. Estimate the costs of the present energy source. Determine the suitability of wind power to satisfy the energy requirements of the operation and estimate the breakeven costs of wind-powered systems in $/kW for those that can be satified. Estimate the number of users versus breakeven cost of wind power for various operations.
PROGRESS: The purpose of this study is to determine the economic feasibility of using wind energy in crop drying and in heating and cooling aspects of food processing on an individual operation; and to what extent wind energy can be used to impact the total industries. A survey was performed to establish the number, size, type, and energy source of crop drying systems on farms and local elevators for grains, peanuts, tobacco, and forages. This was also done for food processing in dairy, meat, fruit and vegetables, and aquaculture. These were then correlated to the availability of wind to provide the necessary energy both on a geographical and a seasonal basis. An analysis was performed to determine breakeven costs of small wind energy systems required to economically supplement or replace present energy sources, estimate payback periods, and compare breakeven costs with projected wind energy systems.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0026
APPLICATION OF WINDMILLS TO APPLE COOLING AND STORAGE
Schetz JA, Klueter HH, Dept. of Aerospace Engineering, Virginia Polytechnic Inst. & State University, *Blacksburg, Virginia, 20461,* (1090-20191-005-C(1))
OBJECTIVE: Design, construct, and operate a windmill power generating system to cool and store apples. Measure the performance of the system as it relates to local wind conditions; and make an economic, cost, and value analysis of wind utilization in cooling and storing of apples.
APPROACH: The research will be conducted by a series of tasks. Take preliminary meteorological measurements at the site. Design an apple cooling plant for 2,000bushels of apples. Specify and order commercial windmill. Build the apple cooling plant. Install the windmill. Perform preliminary field measurements of the system in operation. Conduct wind tunnel tests for performance. Conduct main field measurements for performance of the total system. Perform economic and cost analysis of system. Prepare final report.
PROGRESS: In September and October 1978 several varieties of freshly picked apples were placed in the apple storage facility for a full storage season. The performance and efficiency of the wind system was measured and the keeping quality of the apples was evaluated. An economic analysis of the system was performed and the final report of the project is being prepared.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

2.0027
APPLICATION OF WINDMILLS TO APPLE COOLING AND STORAGE
Vaughan DH, Dept. of Agricultural Engineering, Virginia Polytechnic Inst. & State University, *Blacksburg, Virginia, 24061,* (VA-0331924-1)
OBJECTIVE: Field test an apple cooling and storage facility using a windmill to provide the energy required. Document windmill performance, total system performance, and wind and weather variations. Conduct economic and cost analyses of the tested windmill application to assess the utility and attractiveness of the system in light of the test results and projected advances in windmill technology.
APPROACH: Meteorological measurements, including windspeed, will be made in order to select a site which has "good" wind energy availability. A state-of-the-art apple cooling facility (including building and refrigeration equipment) will be designed to be used as a test bed for the windmill application. The building will have energy conserving measures such as extra insulation. A commercially available windmill will be selected to match the cooling requirement and purchased. Two methods of thermal energy storage will be used. Batteries will be used to store the electrical energy generated by the windmill generator. Electrical energy from the batteries will power the refrigeration system, which will be used to make ice in a tank/thermal exchanger. The ice tank will be used for cooling purposes, especially during the high cooling load period when the apples are loaded into the building. The windmill application will be fully instrumented to recorded windmill parameters, weather, apple environment, and cooling system performance.
PROGRESS: A wind-powered refrigeration facility was evaluated during 1978 for cold storage of apples. The facility included a 10 kW wind turbine generator, nickel-cadmium storage batteries (13 kWh), a 1000-bushel cold storage building (14 m multiplied by 7 m multiplied by 3 m high), a 3 hp d.c. vapor-compression refrigeration system (Freon 12), and an ice fank thermal storage unit (285 kWh). Five varieties of apples were stored at 0 degrees C and 85% relative humidity beginning on September 7. The Electro WVG120G 3-bladed, high-speed propeller-type wind turbine, rated at 10 kW at 10.7 m/s wind speed, was mounted on a 27.4(3)m reinforced radio tower. The cooling system included a centrifugal circulating fam (2000 m 3/h flow rate) driven by a 0.19 kW d.c. motor, compressor and condenser unit (rated capacity of 6.5 kW.
SUPPORTED BY: Virginia State Government.

2.0028
MARINE ADVISORY PROGRAM - NORTH PUGET SOUND
McArdle D, Granger P, Bellingham Vocational Technical Inst., *Bellingham, Washington, 98225,* (A/FP-6)
OBJECTIVE: Provide education and information programs responsive to the important needs of the marine resource users in the northern Puget Sound region (most of five counties): 1. Coordinate a cooperative project among local fishermen, tribes and the Washington Department of Fisheries on early chum enhancement on the Nooksack River. 2. Develop a coordinated effort involving fishermen, retired seniors and local law enforcement people to stop poaching of spawning salmon each fall. 3. Develop a better public understanding of the various aspects of artificially propagating salmon through (a) organizing workshops for K-12 teachers to acquaint them with resource material and field study sites, and (b) continuing the present advisory role with Bellingham's Maritime Heritage Center. 4. Collect and disseminate information on the types of energy-saving technologies becoming available to fishermen and boaters, including sailpowered fishing vessels designed from the keel up, with the other agents.
APPROACH: 1. A cooperative project on early Nooksack chum enhancement could create a new fishery in Bellingham Bay for all fishermen. 2. The first adult fish from our Sea Grant enhancement efforts will be returning this fall and an effort to stop poaching could give more fish a chance to spawn. 3. Through teacher workshops, curriculum uynits on stream ecosystems can be devised and taught to the next generation whose commercial and social activities will interact with those systems. 4. Uncertainities of fuel price and supply and accompanying government policies are generating numerous inqulries; a compilation of resource material on energy-saving technologies can help constituents make better decisions.
PROGRESS: 1. Fifty fishermen participated in business recordkeeping workshops in Anacortes, Blaine, Friday Harbor, and Bellingham to learn to generate better records and become more aware of their costs of operation. 2. Two publications were produced: one on the economic impact of Whatcom County's fishing industry and the other a marine short course notebook for extension educators. 3. Courses and workshops attracted 706 attendees for an average of 6.5 hours of contact per attendee in the past 12 months.
SUPPORTED BY: U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin.

2.0029
APPLICATION OF WIND ENERGY TO WISCONSIN AGRICULTURE
Koegel RG, Straub RJ, Livermore DF, Dept. of Agricultural Engineering, University of Wisconsin, *Madison, Wisconsin, 53706,* (WIS02559)
OBJECTIVE: Predictive capabilities for siting wind generators will be developed along with guide lines for economic decision making. Availability of wind energy for farmstead energy needs will be assessed. Recommendations will be made for rating wind machines.
APPROACH: A predictive model will be developed for wind machine siting which will attempt to predict a site acceptability based on topographical parameters. Existing and generated data will be used to establish a correlation between available wind energy and agricultural energy needs on a seasonal and diurnal basis. Based on these data and model, guidelines will be developed for machine sizing and economic justification and for wind generator rating standards.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0030
EVALUATION OF A WIND ENERGY CONVERSION SYSTEM FOR AGRICULTURAL APPLICATION
Becker CF, Smith D, Radloff HD, Dept. of Agricultural Engineering, University of Wyoming, *Laramie, Wyoming, 82071,* (WYO-148-078)
OBJECTIVE: Secure meteorological data and correlate with performance of a wind energy conversion system (WECS) as related to agricultural farmstead electrical energy needs.
APPROACH: A computer direct digital data acquisition system to monitor wind speed and direction, other meteorological data, electrical consumption used for water heating, home use, feed grinding and other uses at the University of Wyoming Dairy Farm will be constructed to record the data on magnetic tape and display the information in real time for decision making and control. Information on energy received from and supplied to the utility energy grid will also be secured. Energy requirements for various applications and performance of the WECS will be correlated with meteorological parameters.
PROGRESS: Work on the Wind Energy Conversion project consisted primarily of construction, installation, and debugging of basic components. Support towers (13.5 m and 4.3 m) and data acquisition system are in place and the latter is monitoring several meteorological parameters and selected data from the generator which is installed on a 4.3 m tower for testing and performance verification. Monitoring of the energy utilized by the UW Dairy milking complex will begin in the near future.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

2.0031
WIND ENERGY SYSTEMS AND THE LANDSCAPE - PART 3 - LANDSCAPE ANALYSES FOR WIND POWER UNITS ON THE ISLAND OF GOTLAND
Skarback E, Nilsson K, Bergsjo A, Dept. of Landscape Planning, Swedish University of Agricultural Sciences, *Alnarp, Sweden, S23053, Alnarp,* (53-5060-744)

OBJECTIVE: A case study in order to test criteria for siting wind power units in the landscape of Gotland (island in Baltic Sea).
APPROACH: General inventory and landscape analyses in reference to siting possibilities for wind power units. Selection of areas with good siting possibilities. Siting separate windmills with regard being paid to landscape scenery and present land-use.
PROGRESS: 1. 11/77-12/77. Program for Wind Energy Systems and the Landscape. 2. 3/78-10/78. Report: Nilsson, Schibbye, Sellberg, Skarback, Wind Energy Systems and the Landscape, Landscape 43, Alnarp 1978. 3. 3/79-9/79. Report: Nilsson (ed) Wind Energy Systems and the Landscape. Part 2. Visual Problems in connection with large-scale wind energy exploitation. Alnarp 1980.
SUPPORTED BY: Namnden for Energiproduktionforskning.

3. GEOTHERMAL ENERGY

3.0001
THE COMMERCIAL APPLICATION OF GEOTHERMAL RESOURCES IN THE FOOD INDUSTRY IN THE WESTERN STATES
Hanemann WM, Dept. of Agricultural & Resource Economics, University of California, *Berkeley, California, 94720,* (CA-B#-AEC-3869)
OBJECTIVE: Evaluate the economic, financial, and engineering obstacles to the commercial application of hydrothermal geothermal resources in the food industry in the Western states. Special emphasis will be placed on market tactics within the industry and on involving industry leaders in a cooperative investigation of the potential scope for geothermal energy in their industry.
APPROACH: Working in close liaison with firms in the industry we will examine: a) present and future trends in technology to determine compatibility with geothermal energy and the need for appropriate process change, and b) industry economics and present and future trends in market structure and plant location in relation to the supply of geothermal resources. The initial focus will be the fruits and vegetables processing sector, to be followed later by other sectors of the industry.
SUPPORTED BY: California State Government.

3.0002
BIOLOGICAL INDICATORS OF ENVIRONMENTAL QUALITY IN CALIFORNIA LAKES AND STREAMS
Resh VH, Dept. of Entomological Sciences, University of California, *Berkeley, California, 94720,* (CA-B#-ENT-3806-H)
OBJECTIVE: Develop the concept of biological indicators of environmental quality as applied to California's lake and stream environments. Analyze the effect of potential impacting activities (e.g., geothermal energy development, organic and heavy metal effluents) on the energy transfer processes in aquatic ecosystems.
APPROACH: Streams and lakes throughout California will be selected for study. A statistically-sound sampling regime will be developed for quantitative biotic collections and measurements of key water chemistry and physical parameters. Diversity indices, production estimates, and bioassay procedures will be applied in specific cases. A matrix data arrangement will be developed in which biological information, water chemistry measurements, and physical parameters can be used in preparing predictive models of the dynamic interactions occurring in these environments.
PROGRESS: The indicator organism approach is being used in evaluating the effects of potential impacting activities in two major studies. First, an analysis of the ecological impact of mosquito control recirculation ditches on San Francisco Bay marshlands includes an examination of biological productivity and diversity as influenced by mosquito control practices in two marsh types, the first a saltwater marsh (Petaluma Marsh), the second a brackish water marsh (Suisun Marsh). Second, the influence of geothermal energy development and operations on aquatic biota in streams of the Geyser Known Geothermal Resource Area is under investigation. The influence of the severe recent California drought on stream communities is currently under analysis. Research has also concentrated on examining the spatial distribution patterns of aquatic organisms as a function of microenvironmental variation: the influence of sampling variability and life history features on the experimental design of aquatic insect studies has been analyzed in detail.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

3.0003
IMPROVED GREENHOUSE PRODUCTION SYSTEMS
Kohl HC, Dept. of Environmental Horticulture, University of California, *Davis, California, 95616,* (CA-D#-EHT-3334-H)
OBJECTIVE: Devise a greenhouse system oriented to the use of geothermal energy and thermal polluting water, coolant from nuclear power generating reactors, and to the special problems of arid climates. Devise greenhouse production systems oriented to the needs of the amateur plant grower.
APPROACH: Index cultivars of ornamental plants according to maximum, minimum and optimum temperature requirements in order to provide information for development of energy conserving modifications of current greenhouse growing systems. Devise and test crop production systems which utilize multiple layers of plants (particularly at night) to make most efficient use of heated space. Devise a greenhouse system oriented to the use of geothermal energy and thermal polluting water, nuclear power generating reactors and to special problems of arid climates. Devise greenhouse production systems oriented to the needs of the amateur plant grower.
PROGRESS: Simulation model for productivity of chrysanthemum pot plants has been revised on basis of experimental data. Publication indicates that productivity of plants growing at low night temperature is the same as for plants growing at normal night temperature providing LAI is above the critical level (Kohl, Jr. H.C. and Thighen, S.P. 1979). Rate of dry weight gain of Chrysanthemum morifolium in Bright Golden Anne as a function of leaf area index and night temperature (Jour. Am. Soc. Hort. Sci., accepted for publication). Work is started on increasing percentage dry weight in flowers and plants grown at low night temperature. Work is started on increasing leaf expansion rate on plants grown at low night temperatures.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

3.0004
IRRIGATION MANAGEMENT FOR EFFICIENT WATER UTILIZATION AND SALINITY CONTROL
Robinson FE, Dept. of Land, Air & Water Resources, University of California, *Davis, California, 95616,* (CA-D#-LAW-3087-H)
OBJECTIVE: Evaluate the effect of salinity in ground water and geothermal water on plant growth on the East Mesa of Imperial County, California and determine the ultimate repository of the heavy metals contained in the water.
APPROACH: On the Imperial East Mesa Republic Geothermal Lease area trees (Athel, Pinus brutia, and date palm), crops (sugar beet, asparagus, and alfalfa), and climax vegetation (creosote brush and annuals) will be irrigated with both geothermal and ground water in a triplicated randomized block layout. Analysis of variance of elemental concentration of soil and plants will be conducted via cyclotron analysis by the Crocker Nuclear lab. Previous findings of this project evaluated the influence of 877 and 1350mg/l TDS water on several crops in Imperial Valley. This revision will evaluate 1600 mg/l TDS ground water and 2000 mg/l geothermal water.
PROGRESS: To evaluate the effect of salinity increases on crop yield and soil salinization, water was artificially salinized and applied by sprinkler irrigation to crops on a clay and a sandy clay loam. Comparison of water at the initial 877 mg/l total dissolved solids and water raised to 1,350mg/l showed significant yield reduction in snap beans, carrots, and onions at the higher level. Reductions in yield were of the same order to magnitude as those predicted. Two management systems were outlined: 1) intermittent leaching by supplying adequate water to the crop but allowing buildup of salt in soil with soil chiseling and leaching in three year intervals; and 2) continuous leaching by applying water at 0.75 times the rate of evaporation from a Class A USWB pan on the clay and 1.30 times the pan evaporation on the sandy clay loam. The first management system was more efficient in water use. The second management system, while less water efficient, offers promise of higher energy and labor efficiency. Study of nitrate fertilization on durum wheat led to the conclusion that three applications of N at 90 kg/ha (80 lbs/acre); first at preplant, second at tillering, and third at boot stages led to the highest yield at the lowest yellow berry content. Lower amounts of nitrogen ran the risk of yellow berry content greater than 25% and higher amounts ran the risk of significantly greater lodging.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

3.0005
PLANT ECOPHYSIOLOGY
Wallace A, U.S. Dept. of Energy Lab. of Nuclear Med. & Radiation Biol., University of California, *Los Angeles, California, 90024,* (000692)
OBJECTIVE: Plant ecophysiology of desert and other plants to a large extent involves basic research at both plant and ecosystem levels of native vegetation in deserts. Baseline data for environmental impact is provided. Multitechnology is involved in that desert areas of concern are involved in coal burning, nuclear fission, and geothermal activities. Two of the activities in the project (nitrogen fixation with N15 and N13 as tools in deserts and use of reclaimed sewage water in hydroponic crop culture) also relate to energy conservation. Desert ecophysiology studies include survival, succession, primary productivity both above and below ground, interactions of species in populations, and comparative mineral status. The results from these basic studies are being used in a cooperative study to develop useful and practical guides to arid land restoration procedures. The last activity is expanded to trace metal pollutants in both desert and economic plants. Frequency distribution phenomena for trace metals in different populations of different areas are being developed. Threshold phytotoxicity for a wide range of elements is being developed with consideration for interactions. A large effort in cooperation with others is devoted to ecological and agricultural aspects of transuranium elements of importance in the nuclear fuel cycle.
SUPPORTED BY: U.S. Dept. of Energy, Office of Health & Environmental Research.

3.0006
GEOTHERMAL ENERGY FOR SUGAR BEET PROCESSING
Seidman JJ, Energy Systems Management Division, Thompson Ramo Wooldridge Inc., *Redondo Beach, California, 90278,* (97248)
OBJECTIVE: The project objective is to design, build, operate and evaluate geothermal processing facility for sugar beets.
APPROACH: The approach is to exploit existing resources to develop geothermal energy for direct generation of steam and heat to be used in processing sugar beets and pulp. Geothermal energy will replace most current fossil fuel in a commercial installation.
PROGRESS: Resource analyses have been completed (temperature, resistivity, seismic, geological). Completed preliminary system design based on 350 degrees brine. Submitted final environmental report. Established preliminary economic feasibility of the system. Completed well design, drilling and completion plans, sub-contractor selection, and site preparation.
SUPPORTED BY: U.S. Dept. of Energy.

3.0007
SUSANVILLE GEOTHERMAL ENERGY PROJECT
Edwardes PA, Susanville City Government, *Susanville, California, 96130,* (AC03-79ET27040)

OBJECTIVE: The objectives are the development of two low-temp (170 degrees F) geothermal wells not expected to exceed 200 feet in depth, the installation of some 10,000 feet of insulated transmission pipe lines and an uninsulated return line, and the retrofitting of 14 public buildings within the City of Susanville to geothermal energy. The residual heat will be cascaded through a Park of Commerce expected to include greenhouses, confined animal raising, and other agri-industry business.
SUPPORTED BY: U.S. Dept. of Energy.

3.0008
INTENSIVE CULTURE OF TILAPIA IN GEOTHERMAL WATERS IN THE SAN LUIS VALLEY, COLORADO
Flickinger S, Dept. of Fisheries & Wildlife Biology, Colorado State University, *Fort Collins, Colorado, 80523*, (COL00067)
OBJECTIVE: Develop techniques to spawn tilapia year-round and to have only males for rearing either through early sorting or through hybridization to produce all male offspring.
APPROACH: Brood fish will be held under various photoperiods to determine what length induces spawning and what length inhibits spawning. With controlled spawning to produce large numbers of offspring at the same time, grading to sort faster growing, and hence larger, males will be tried for accuracy in sorting sexes. Hybrid crosses will also be made to test for unusual sex ratios.
PROGRESS: Spawning of Tilapia aurea was studied in steel tanks with concrete floors, under various photoperiods. Sex ratio was 5 males to 25 females per tank, using tanks that were 198,259, and 330 cm in diameter with 56 cm depth water. Using this set-up, mortalities by fighting were eliminated. Fourteen hours of light followed by 10 hours of dark achieved more spawn than any other light regime studied. Under 0, 6, and 24 hours of light per day the fish were found to produce diminishing amounts of eggs until nearly stopping production at 9 weeks. Ten hours light per day, 12 hours light per day, and a treatment of 10 minutes of light each hour for 12 hours per day induced fish to spawn but at lower levels than the 14-hour photoperiod. Results show that tilapia could be spawned year-round with a 14-hour photoperiod (with water temperature at 26 degrees C). Further research is being conducted to find optimum densities, water depth, sex ratio, and tank size for the hybridization of tilapia to produce all male offspring.
SUPPORTED BY: Colorado State Government.

3.0009
TARGETING OF GEOTHERMAL RESOURCES IN DELAWARE
Woodruff KD, State Geological Survey, University of Delaware, *Newark, Delaware, 19711*
OBJECTIVE: The project is designed to assist DOE and its contractors in preliminary determination of the geothermal resources potential of Delaware.
PROGRESS: To date, work has included (1) administrative assistance to DOE contractors in preparation for the drilling of geothermal gradient holes, (2) temperature and other geophysical logging of gradient test holes, and (3) preparation of a Bouguer gravity map of portions of southern Delaware. Preliminary interpretations have been made of the gravity and other geophysical data from the standpoint of identifying structures or geologic features that would have geothermal implications. Final results would include recommendations for future drilling sites and prediction of temperatures that might be expected at given depths. Additional gravity mapping has been done and emphasis has been placed on interpretation of gravity data collected during the previous contract period.
SUPPORTED BY: U.S. Dept. of Energy, Office of Resource Applications.

3.0010
R AND D OF INFORMATION ON GEOTHERMAL DIRECT HEAT APPLICATION PROJECT
Stitt WC, I C F Inc., *Washington, District of Columbia, 20520*
OBJECTIVE: The objectives are to: (1) review data available from DOE-funded geothermal direct heat application projects; (2) establish an automated and easily useable information system; and (3) prepare a series of reports that will provide investment-oriented information. Report topics will include: (1) resource assessment; (2) well drilling and resource development; (3) system design; (4) construction and operation; (5) space and district heating; (6) industrial processes; (7) agricultural systems; (8) economics; (9) environmental and institutional considerations; and (10) potential for future development.
SUPPORTED BY: U.S. Dept. of Energy.

3.0011
FISH CULTURE USING GEOTHERMAL WATER
Beleau M, Forest Wildlife & Range Experiment Station, University of Idaho, *Moscow, Idaho, 83843*, (IDA-CFU-0057)
OBJECTIVE: Assess the economic feasibility of raising fresh water fin fish in geothermal waters.
APPROACH: The objective will be attained by raising carp and channel catfish in natural geothermal waters and in non-geothermal waters. The growth rates, hematological parameters, bioaccumulations of heavy metals, and proximate analyses of white muscle will be measured and used as validating criteria.
PROGRESS: An evaluation of geothermal aquaculture has demonstrated significant potential. Geothermal water from a 1525 m well, flowing under artesian pressure, was reduced in two cooling ponds and maintained within a 22-26 degrees C range. Channel catfish (Ictalurus punctatus) and common carp (Cyprinus carpio) were intensively cultured, utilizing growth programming with several rations. Growth rates remained high throughout the study and physiological parameters monitored during the study indicated no difference between fish reared in geothermal and non-geothermal water. Further investigations are underway to determine if these cultured fish can be carried through a complete life cycle by spawning and maintaining a viable F(1) generation.
SUPPORTED BY: Idaho State Government.

3.0012
THERMAL WATER UTILIZATION IN TREE BREEDING AND WOOD PRODUCTION PROJECT
Wang C, Howe JP, Dept. of Forest Resources, University of Idaho, *Moscow, Idaho, 83843*, (IDA-ES-0090)
OBJECTIVE: Selective breeding of forest trees for improved growth rate and wood quality for the utilization of thermal water.
APPROACH: Initial field trial experiments were established at the Idaho Falls ERDA site for evaluation and seiection of best genotypic response in growth and their optimum cycle and level of thermal water, ground heating and other treatments. The test materials include selected clones of inter-species hybrid poplars, indigenous conifers and exotic and indigenous species for Christmas trees and ornamentals.
PROGRESS: Biomass production experiment continued at the Hanford Reservation plantations. The clones of hybrid produced 8 tons of above ground biomass per acre per year (oven-dry weight).
SUPPORTED BY: Idaho State Government.

3.0013
RURAL RESIDENTIAL APPLICATION OF GEOTHERMAL HEAT PUMP
Griggs DA, Performing Institution Not Reported.
OBJECTIVE: This project will demonstrate to individuals an alternative energy method for heating and cooling their residential environment. The project is in rural Minnesota yet applicable to rural/suburban homes throughout the region. The goals of the project is to, reduce or in many cases eliminate the use of non-renewable energy resources such as fuel oil. It is expected that this project will have a 100% savings of fuel oil, a 60% to 70% savings in operating costs, considering that this project also replaces the conventional air conditioning system. Another objective of this project is to educate the energy consumer in the use of geothermal energy sources and to graphically display the pay off rate using operational costs versus installation expense.
SUPPORTED BY: U.S. Dept. of Energy.

3.0014
MISCELLANEOUS RESEARCH IN AGRICULTURAL ENGINEERING
Larsen WE, Erickson LR, Dept. of Agricultural Engineering, Montana State University, *Bozeman, Montana, 59715*, (MONB00111)
OBJECTIVE: Research the feasibility of new problem areas. Short-term investigations for the solution or urgent problems. Coordinate preliminary parasitic research with existing research projects.
APPROACH: Funds for feasibility studies or investigations of new problem areas are allocated on a competitive basis. New staff members and projects are budgeted from this project until a formal project is approved and budgeted.
PROGRESS: 1. Rangeland Reclamation Equipment. A cooperative agreement was entered into with the USDA Livestock and Range Research Station (LRRS) in Miles City, MT. The Agricultural Engineering Department has agreed to design and construct a rangeland reclamation device for the LRRS. The machine is partially complete, with a delivery date scheduled for April/May 1980. 2. Proposal for a Geothermal Greenhouse. A portion of a grant proposal development project was undertaken in the Spring of 1979 at the request of Ray Bozlee, Montana Department of Corrections, Deer Lodge, MT. Alternatives for a geothermal heated greenhouse were investigated. A preliminary design was developed for an energy efficient custom greenhouse structure. The project grant specified a prefab, commercially available greenhouse as the most cost effective structure, based on intended use of the building. 3. A position paper was prepared for the Montana Legislature on Transportation of Grain by Pipeline and other methods. The materials handling aspects of grain were handled by Agricultural Engineering. A preliminary response to the 1979 HJR61, Legislation of Montana. 4. Assistance was given to the various units of the Agricultural Experiment Station in the filing of water rights as required by Senate Bill 76 of the 1979 Legislature.
SUPPORTED BY: Montana State Government.

3.0015
PRODUCTION OF MACROBRACHIUM ROSENBERGII (GIANT MALAYSIAN PRAWN IN NEVADA)
Taylor R, Dept. of Veterinary Medicine, University of Nevada, *Reno, Nevada, 89507*, NEV00355)
OBJECTIVE: Determine the feasibility of raising prawns in power plant effluents and/or geothermal waters in Nevada.
APPROACH: Obtain prawns, conduct liveability tests, and prepare for production. Grow larvae in brackish water, prepare ponds, and study pond water parameters. Stock ponds with juveniles, feed, maintain, and harvest adults. Study the market.
PROGRESS: A one acre pond was stocked with 60,000M. rosenbergii new post larvae in April 1979. The pond was operated for 8 1/2 months when low water temperatures required complete harvesting of all prawns. Prior to that, harvests of market size prawns had been carried out starting 4 1/2 months post stocking at 3-week intervals. Total prawn weight harvested amounted to 916 pounds of which 656 pounds were market size (6-10 count prawns). Problems were experienced with both bird and fish predation on the prawns. In another experiment prawns which were not fed but kept in a pond fertilized daily with cow manure weighed only 1/3 as much as a control group that was fed a pelleted feed. Experimentation with floating net structures to hold prawns in a 60 acre power plant cooling pond has been unsuccessful. Problems have been caused by prawns escaping small openings in the net as well as fish entering the nets.
SUPPORTED BY: Nevada State Government.

3.0016
ECONOMIC EFFICIENCY, EQUITY, AND IMPACT ASSOCIATED WITH GEOTHERMAL RESOURCE DEVELOPMENT IN OREGON
Obermiller FW, Dept. of Agriculture & Resource Economics, Oregon State University, *Corvallis, Oregon, 97331*, (ORE00111)
OBJECTIVE: Inventory the location and extent of developable geothermal resources in Oregon for different energy prices and investment costs. Evaluate private benefits and costs of geothermal development for different leasing arrangements,

ownership structures, degrees of risk and uncertainty, energy prices, and Btu-equivalency values. Evaluate public benefits and costs of geothermal developing including effects of different State and/or federal regulations and formulate recommended guidelines as appropriate.
APPROACH: Assemble and catalogue secondary data on Oregon geothermal resources. Simulate costs and returns to private geothermal resource owners and public resource managers for alternative combinations of natural and market risk and uncertainty, energy prices, and development costs. Project local economic effects for each alternative using a county-level input-out-put model. Evaluate time paths of social benefits and costs using regionalized benefit-cost analysis.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

3.0017
FLORAL GREENHOUSE INDUSTRY GEOTHERMAL ENERGY DEMONSTRATION PROJECT
Wright RM, Utah Roses Inc., *Sandy, Utah, 84010*
OBJECTIVE: The objectives are to drill a geothermal well on the location of the existing greenhouse, and to heat the greenhouses with the geothermal fluids obtained from the well. This will also demonstrate the use of geothermal energy for space heating applications in a populated area, as well as the availability of geothermal energy in the Salt Lake City area and other similar locations in the Western US. After the well is successfully completed, the greenhouse will be retrofitted to utilize the heat, depending on water temperature and water characteristics. If sufficient flow and temperature is developed, hot water will be offered to surrounding homes and businesses in a district heating project.
SUPPORTED BY: U.S. Dept. of Energy.

3.0018
ECOLOGICAL EFFECTS OF EXTRACTION OF GEOTHERMAL ENERGY
Troedsson T, Dept. of Forest Soils, Swedish University of Agricultural Sciences, *Uppsala, Sweden, S75007 Uppsala,* (780635-4)
OBJECTIVE: To study the alterations in the ecological environment caused by the extraction of geothermal energy.
APPROACH: Full scale experiment to determine the effect on soil processes of varying extraction rates, primarily on garden plants. Soil physics - measurements of energy flows and water flows within the test surfaces, using methods developed in the NFR project "The Ecology of Coniferous Forest Country". (NFR is the Swedish Natural Science Research Council.) Soil chemistry - studies in this field lie entirely within the framework of traditional pedological methods. Soil biology - the effects on the soil processes are gauged by various activity measurements. Soil breathing is measured continuously using portable gas chromatography equipment. Earthworms have been chosen for intensive study of their behavior at various extreme levels of extraction. Cultivation conditions - the practical consequences of energy extraction for cultivation conditions are gauged by cultivating temperature-sensitive "indicator plants". The methods of this project exist in theory, but not for "average land for detached-house development".
SUPPORTED BY: Statens Rad for Byggnadsforskning.

4. ENERGY FROM AGRICULTURAL PRODUCTS AND RESIDUES

4.0001
ANIMAL WASTE UTILIZATION AND TREATMENT SYSTEMS
Hill DT, Dept. of Agricultural Engineering, Auburn University, *Auburn, Alabama, 36830,* (ALA00501)
OBJECTIVE: Determine optimum harvesting, storing and processing procedures in utilization of animal wastes as feedstuffs, sources of energy and culture media and determine the response of animals to diets containing animal waste products and process by-products. Optimize waste treatment processes and management techniques to minimize energy requirements, improve utilization and enhance management efficiency, and evaluate methods of improving air and water quality in systems which recirculate waste water.
APPROACH: Collection efficiency of cattle waste on slatted and solid concrete floors will be studied. Cattle waste will be fermented under controlled conditions and mixed with other feed ingredients to study conversion efficiency. Studies on cattle and poultry manure as fish feeds and pond fertilizer will be conducted. Research on algae production and feeding and refeeding anaerobic digestion residues and optimization of these processed will occur. Solid-liquid separation and utilization of these components of flushed waste will be studied.
PROGRESS: This project was activated on 1 July 1979 as a revision of Regional Research Project S-89. Work in Alabama will center on reuse of animal waste through a number of different techniques. Direct refeeding of swine waste after screening will be evaluated. This raw waste will be added as a supplement to a conventional ration, with the waste replacing a portion of the new feed. Utilization through anaerobic digestion by utilizing a field scale digester for approximately 400 finishing pigs is also planned. Experiments will include varying the detention time and feed rates as well as researching new operating modes and pretreatment options. Mild acid and alkaline hydrolysis of the waste before digestion is one pretreatment alternative to increase digestiblity. A third utilization technique would involve research with microalgae production for single-cell-protein supplements to the swine ration. The feed ingredient targeted for replacement is soybean meal as the amino acid content of algae meal is almost identical. The work will involve laboratory, bench and pilot scale equipment and the involvement of microbiology and animal scientists.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0002
EFFECT OF ANIMAL AND OTHER ORGANIC WASTES ON SOIL PROPERTIES AND POLLUTION ABATEMENT
Hileman LH, Dept. of Agronomy, University of Arkansas, *Fayetteville, Arkansas, 72701,* (ARK 00546)
OBJECTIVE: Continue chemical analysis of poultry manure, both solid and liquid. Expand the analysis to include other animal, industrial, and municipal waste. Determine the effect of these wastes on soil chemical and physical properties. Study ability of local soil types to accept the various wastes with respect to surface and underground water, soil chemistry, waste degradation, and end products. Investigate new methods of land disposal of waste materials.
APPROACH: Chemical analyses of the waste and the soil at the site of disposal will be accomplished by latest acceptable methods. More than two of the objectives will be studied at any one time since they are all related. The actual number and kind of field experiments cannot be projected at this time. Data will be published as soon as obtained in order to make it available immediately.
PROGRESS: Experiments using cotton gin trash compost were established on the crops of corn, cotton, greenbeans, and sorghum. A 3-year experiment on cotton was completed. A manure, compost experiment is being conducted in cooperation with the Southwest Branch Experiment Station and this work will be expanded next year. A series of experiments designed to find a method of controlling odor in liquid manures during land application. Initial survey indicates methane production offers a high potential for odor control with energy and nutrient conservation. Land application still is the most satisfactory disposal/utilization of organic wastes except hazardous wastes. Using organic wastes, wood, compost, pulp, as a part of potting soil mix is investigated. Presented a paper on the use of residue from methane and alcohol production to the Biogas and Alcohol Production Seminar in Chicago, October 1979.
SUPPORTED BY: Arkansas State Government.

4.0003
UTILIZATION OF ORGANIC WASTE MATERIAL AS FEED FOR RUMINANTS
Stallcup OT, Rakes JM, Daniels LB, Dept. of Animal Science, University of Arkansas, *Fayetteville, Arkansas, 72701,* (ARK00753)
OBJECTIVE: Determine nutritive value for residues of field and horticultural crops, food processing wastes and wood products that occur in the harvesting processes or as an aftermath of food and wood processing. Determine the economic value of further processing of the above listed materials in order to render them more amenable to transporting and mechanical handling and/or to enhance their nutritive value. Determine the accumulation of chemical residues or other substances that could possibly render then unsafe for use in ruminant nations. Develop effective methods of disposing of organic residues avoided by cattle.
APPROACH: Use chemical analyses to estimate nutritive value of wood products and residues, field crop residues, horticultural crop residues, food processing wastes and broiler house litter. The use of in vitro digestibility and digestion trials with steers as a screening device to estimate nutritive value. Feeding trials with steers and/or milking cows to determine the utilization of materials studied. Treatment of residues by dehydration, pelleting, grinding, ensiling, enzyme addition and chemical treatment to preserve, render them easier to handle or increase digestibility. Incorporation of manure and organic residues into soil to reduce pollution and add nutrients. Also its use for feed, fuel or methane production.
PROGRESS: Samples of grain sorghum refuse have been collected at weekly intervals for 5 weeks from 9 hybrids. The resulting forage was further partitioned into stalk, head stem and leaf and sheath. Crude protein content and In Vitro dry matter digestibility (IVDMD) are being determined on these samples to determine effects of maturity, and weathering on nutritive value. One lot each of grain sorghum refuse and soybean refuse were harvested and baled. Each lot was further divided into untreated and treated sublots. The treated portion of each refuse lot was placed in a plastic covering and anhydrous ammonia added at approximately 4% of dry matter. The covering was sealed and the refuse allowed to remain in the ammonia atmosphere for one month. The refuse was then removed, sampled and chopped. Digestion trials are currently underway with Holstein steers to determine nitrogen and soybean refuse. Small samples of prairie hay and ground sorghum and soybean refuse were placed in plastic coverings also and subjected to anhydrous ammonia (4%) for one month.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0004
CONVERSION OF FRUIT, VEGETABLE AND OTHER FOOD PROCESSING RESIDUES TO FUELS
Pavlath A, Krochta J, Robertson G, Western Regional Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Albany, California, 94710,* (5102-20510-024)
OBJECTIVE: Contribute to agricultural energy self-sufficiency by deriving from processing wastes energy that may be recycled for processing operations.
APPROACH: A major study will be conducted on the pyrolytic degradation of various carbohydrates, first using model compounds. Pyrolysis will be studied in oxidative, reducing and inert atmospheres utilizing various catalysts to obtain either fuel-like materials such as hydrogen, methane, etc. or to produce intermediate degradation products such as oiligosaccharides (e.g., levoglucosan) which would be more easily biochemically convertible to fuel. In another effort, the direct biochemical conversion of carbohydrates will be studied either directly to fuel-like materials, or to intermediates which then could be more easily converted to fuel by chemical reactions. Special emphasis will be given to processes, such as continuous fermentation, that would be suitable to on-farm application.

SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0005
GENETIC CONTROL OF YEASTS IN WINE MAKING
Fogel S, Mortimer RK, Dept. of Agricultural Genetics, University of California, *Berkeley, California, 94720,* (CA-B#-GEN-2947-H)
OBJECTIVE: Improve wine quality and acceptability by yeast breeding; and select strains of high alcohol yield which could provide automotive fuels at commercial levels.
APPROACH: Though the role of yeasts in wine-making is widely appreciated, relatively little effort has been directed at using genetic approaches to develop yeasts that may produce higher quality wines. The genetics of yeast is firmly established and procedures for hybridizing wine yeasts with laboratory strains or with other wine yeasts are well worked out. Inter-specific hybrids that bring together different desirable qualities such as alcohol tolerance, yield, and cold-resistance will be constructed and evaluated.
PROGRESS: Not funded during 1978, hence no activity on this project.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0006
UTILIZATION OF ANIMAL, CROP AND PROCESSING RESIDUES
Dobie JB, Miller GE, Hills DJ, Dept. of Agricultural Engineering, University of California, *Davis, California, 95616,* (CA-D#-AER-2971-H)
OBJECTIVE: Investigate means and processes for obtaining greater utilization of animal, crop, and food processing plant wastes by recycling, conversion, and energy recovery techniques. Control and reduction of air, water, and soil pollution would be a basic consideration.
APPROACH: Laboratory and field studies would be conducted on open field burning of crop residues and pyrolysis and incineration for any recovery; animal and food processing wastes would be examined for recycling to animal feeds; all types of wastes would be studied in soil plots for recovery of nutrients and encouragement of soil bacteria conversion to useable plant nutrients.
PROGRESS: A rotary screen was used to separate soil and some leaf fines from plant material at a commercial gin during the 1977 ginning season. Gasification tests with the cubed plant materials showed that ash slagging is a serious problem with a down-draft gasifier. Trials have been run on composting screened cotton gin trash. The optimum composting moisture content is 35% with a mixing frequency of 4-7 days. Weed seeds and verticillium wilt organisms appear to be destroyed in the composting process and the reduction of several pesticides is presently being assayed. Several studies have been made on producing methane gas from dairy manure, tomato cannery waste and barley straw. When combining several wastes for methane digester feed the optimum combinationappears to be for a "non-lignin carbon to nitrogen" ratio of 25 for the mixture. Studies with operating digesters with a relatively high solids content (20% TS) have been successful. A project was completed on characterizing the wastewater from egg grading plants. Samples from several plants over a 10 week period indicated the organic content of the effluent to be about ten times as strong as domestic sewage. The wastewater was found to be amenable to both aerobic and anaerobic biological stabilization. The 3m 3 chicken manure digester studies continued with a range of volatile solid loading rates at 25-day and 15-day hydraulic detention times.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0007
GAS PRODUCER RETROFITTED PORTABLE NATURAL GAS ENGINE FARM IRRIGATION POWER PLANT
Goss JR, Dept. of Agricultural Engineering, University of California, *Davis, California, 95616,* (CA-D#-AER-4027-SG)
OBJECTIVE: Design, develop, and test a system to pump on-farm irrigation water using crop residues as the fuel source. A natural gas engine-electric power plant retrofitted with a gas producer to convert crop residues into low-Btu gas for the engine fuel will be designed to deliver about 95% of the rated horsepower.
APPROACH: Determine the type of gas producer for high ash crop residue fuels, design for the amount of pressurizing of the engine fuel change of low-Btu gas to deliver about 95% of the engine horsepower rating on natural gas and design, construct, and test the portable power plant as a unit in a laboratory setting.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0008
POULTRY PRODUCTION AND ENVIRONMENTAL QUALITY
Wilson WO, Vohra P, Dept. of Avian Science, University of California, *Davis, California, 95616,* (CA-D#-AVS-3372-RR)
OBJECTIVE: Determine characteristics of poultry house pollutants and factors influencing their relationship to environmental quality. Determine the effects of poultry house environment and management practices on production efficiency and product quality.
APPROACH: Data from laboratory studies on methods of stabilizing poultry manure to make it less attractive to flies will be collected. Field studies will be made to compare different housing types, e.g., deep pit, flush-out, and open houses, as sources of ammonia, odor and dust. An experimental model of an anaerobic digestor of poultry manure will be operated at different loading levels to determine the amount of methane generated. The residue will be studied as a fertilizer and possibly as an animal feedstuff. Noise inside several houses filled with chickens will be characterized with regard to its frequency range and decibel level.
PROGRESS: A number of open and environmentally controlled poultry houses were studied for light intensity, relative humidity, noise level, dust level, ammonia concentration, and air movement. The data will appear in the final report of the regional project W-136. The work on various loading rates of volatile solids as influencing gas production from chicken manure was continued and the final report is under compilation. If the regional project is extended further, characterization of poultry house dust will be started.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0009
BIOCONVERSION OF DISTILLERY AND WINERY WASTE
Williams LA, Dept. of Viticulture & Enology, University of California, *Davis, California, 95616,* (CA-D#-VIT-3841-H)
OBJECTIVE: Develop bioconversion processes based on winery and distillery wastes which allow economic recovery of by-products or energy while reducing pollution problems.
APPROACH: Survey and chemically characterize winery and distillery waste streams. Survey and screen for organisms which perform interesting bioconversions of waste or its major components. Determine important bioconversion process parameters such as kinetic constants, yield factors, temperature limits, etc., in laboratory scale equipment. Perform economic analysis to determine desirability of pilot scale experiments.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0010
METHANOGENIC MICROORGANISMS FOR DEGRADATION OF CELLULOSIC AGRICULTURAL WASTES
Mah RA, Kohler GO, School of Public Health, University of California, Los *Angeles, California, 90024,* (5102-20520-021A(2))
OBJECTIVE: To isolate and study the methanogenic and other organisms involved in anaerobic fermentation of cereal straws to yield methane and animal feed residue.
APPROACH: Various microorganisms, both acid-formers and methanogens, will be isolated from anaerobic fermentors. Organisms will be identified and information obtained regarding their metabolism.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0011
CHARACTERIZATION OF LIVESTOCK WASTES
Chang AC, Pratt PF, Dept. of Soil & Environmental Sciences, *Riverside, California, 95202,* (CA-R#-SES-2774-H)
OBJECTIVE: Explore the material utilization potential of livestock wastes through proper characterization wastes.
APPROACH: Determine the particle size distribution pattern of livestock wastes and the effect of chemical and biological composition. Study the anaerobic digestibility and gas producing potential of each size fraction. Examine the electrostatic properties of waste solids in aqueous solutions of suspension.
PROGRESS: In recent years, there has been a renewed interest in producing methane gas by anaerobic fermentation of organic wastes. The gas producing potential of each waste, however, can only be estimated by using the cumbersome bench scale bio-assay procedure. A study was initiated to develop a quick method to assess the anaerobic digestibility of organic wastes. The development of this procedure is based on correlating biodegradability with the thermal destruction of the waste. Preliminary investigations using municipal sewage sludge digesters demonstrated good relationships of anaerobic solid destruction and thermal destruction. Plans were made to set up bench scale anaerobic digesters characterizing anaerobic degradability of various animal wastes and testing the applicability of the proposed quick method in determining digestibility.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0012
CONVERSION OF FEEDLOT WASTE INTO SINGLE CELL PROTEIN ANIMAL FEED
Harper JM, Tengerdy RP, Dept. of Agricultural Engineering, Colorado State University, *Fort Collins, Colorado, 80523,* (COLV02879)
OBJECTIVE: Agricultural waste can be a resource for feed and fuel production instead of a pollution burden. Animal manure represents the most concentrated and most abundant form of this resource.
APPROACH: The main ingredients in feedlot waste are undigested cellulose and nitrogenous compounds. These ingredients may be converted to a valuable feed called single cell protein, or to fuel by microbial fermentation.
SUPPORTED BY: U.S. Dept. of Agriculture.

4.0013
EVALUATION OF METHANE PRODUCTION FROM WET STILLAGE AND THE NUTRITIONAL VALUE OF THE RESIDUE
Jantzen D, Dept. of Animal Science, Colorado State University, *Fort Collins, Colorado, 80523,* (XB-0-9076-01)
OBJECTIVE: The technical objectives are to: (1) determine the biodegradability and kinetic constants for anaerobic digestion of grain alcohol stillage; and (2) assess the value of the digester effluent as a cattle feed.
APPROACH: Corn stillage from an alcohol plant will be digested to determine the methane yield, biodegradability, and rate constants under both mesophilic and thermophilic conditions. The composition of the effluent from the digesters will be analyzed to provide an indication of the potential value of the effluent as a cattle feed. An economic analysis will be performed to test the hypothesis that it is more economical for the alcohol plant to use the methane produced from stillage to fuel part of the alcohol operation and feed the effluent to cattle, rather than feeding the stillage directly to the cattle without first removing some energy. If the process of digestion of the stillage prior to feeding it to cattle is shown to be economical, then potential gasohol plants would be able to obtain a higher value for their stillage. If the methane produced in the digestion process turns out to be a significant portion of the energy required to run the alcohol plant, it would provide additional flexibility in locating and operating the plant.
SUPPORTED BY: U.S. Dept. of Energy.

4.0014
ENERGY IN WESTERN AGRICULTURE - ADJUSTMENTS, AND ALTERNATIVES
Ward GM, Dept. of Animal Science, Colorado State University, *Fort Collins, Colorado, 80523,* (COL00217)
OBJECTIVE: Estimate current patterns and amounts of energy inputs currently utilized in western agriculture. Assess contributions of, and prospects for, alternative technologies and policies for dealing with changes in energy availability.
APPROACH: Determine the fossil fuel energy requirements for various beef production options, including requirements for ranch management, feed crop production, feedlot operations, feed processing, and transportation requirements for cattle and feed. Particular attention will be given to the energy trade offs of providing additional cattle feed from pasture and range improvement, to collecting processing crop residues and wastes, to processing feeds to increase nutritive value, and to increasing crop production from prime land. Finally to recommend alternative production systems and energy policies which will conserve energy use per unit of beef production.
PROGRESS: Work during the past year involved a study with a model of the U.S. beef industry to determine the relation between minimizing energy input for U.S. beef production and minimizing cost. The analysis suggested that energy prices would have to increase about 2.5 fold before energy minimization would be effective and changes in production away from feed grains produced under irrigation would be necessary. Comparisons were made also of forage and grain fed beef production system for energy efficiency. The apparent low-energy inputs for grazing systems were found to require about one-half as much fossil fuel per unit of beef but land constraints in the U.S. would limit beef to no more than 60% of the current supply. These results have considerable relevance to public policy decisions regarding land use, set aside land, feed grain production and water use. Future work is designed to model individual production systems so that the effect of minimizing inputs of energy or other resources can be estimated in terms of beef quantity and quality. Attention will be given to competition for biomass between livestock and energy fueled stock uses.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0015
OPTIMIZATION OF ENERGY USE FOR LIVESTOCK PRODUCTION
Ward G, Dept. of Animal Sciences, Colorado State University, *Fort Collins, Colorado, 80523,* (INT79-18660)
OBJECTIVE: The objective of this collaborative research with Professor N. Todorov of the Agricultural University in Stara Zagora, Bulgaria, is to modify and use mathematical models to integrate the results of a variety of research programs at the Colorado State University and in Bulgaria into a system for analysis of alternative uses for crop residues and agricultural wastes.
APPROACH: A number of mechanical, chemical, and enzymatic methods to improve nutritive value of biomass will be evaluated and the cost effectiveness and net energy efficiency for field use will be determined. The analysis of research data from Colorado State University and Bulgaria will determine the most advantageous alternative uses of wastes for feed, fertilizer, and fuel. This cooperative research is being performed under the NSF-Bulgarian program.
SUPPORTED BY: U.S National Science Foundation.

4.0016
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
Morrison SM, Ward JC, Hansen RW, Dept. of Microbiology, Colorado State University, *Fort Collins, Colorado, 80523,* (COL00222)
OBJECTIVE: Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production, and other potential uses.
APPROACH: Examine the role of feedlot waste (FLW) particle size on chemically modifying manure for fermentations and explore the dual culture (mold and yeast) fermentations process as a means of converting cellulosics to carbohydrates for yeast protein growth. The fermentation of fractionated and pretreated manures are used to increase biomass in an energy self-sufficient system to enhance the value of manure for refeeding; study to improve the protein recovery from FLW. Study harvesting practices to provide greatest retention of valuable manure constituents while minimizing detrimental environmental impacts. Modified manures are to be examined as substrate for optimizing bacterial methane producion. Make further evaluation of the sodium content in feeds to reduce runoff salt pollution by better management of feeds. Use of solar radiation transparent coverings over the feedlot area to eliminate precipitation, evaporate feedlot moisture and reduce the volume of manure to be managed as well as controlling odors is to be examined.
PROGRESS: Modification and Utilization of Manure Components for Feed and Energy. Various forms of feedlot waste (FLW) were enzymatically hydrolyzed with cellulase complex from Trichoderma reesei plus Beta-glucosidase of Aspergillus niger. Fifty percent of cellulose was saccharified (70% glucose). Saccharide concentration too low for economic alcohol production, but the 1/ is favorable for producing single cell protein. To increase cellulase from T. reesei a search for derepressed mutants to overcome glucose repressions appears favorable. Work continued on a two-stage methane generation system (acidogenic and methanogenic). The two-stage generation provided a statistically significant increase in methane over a single step system. Solids destruction in both systems were the same. High partial pressures of hydrogen and carbon dioxide reduced the yield of acid substrates in the acidogenic fermentation.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0017
CONVERSION OF FEEDLOT WASTE INTO SINGLE CELL PROTEIN ANIMAL FEED
Tengerdy RP, Harper JH, Dept. of Microbiology, Colorado State University, *Fort Collins, Colorado, 80523,* (COLV02880)
OBJECTIVE: Convert feedlot waste (FLW) into animal feed and fuel.
APPROACH: This will be accomplished in a two stage microbial fermentation process. Since the cellulose left in FLW after the ruminant digestion process is resistant to microbial degradation in an anaerobic digester, the cellulosic fraction of FLW will be separated, physically or chemically pretreated, and then fermented with Trichoderma viride in an aerobic fermentation. This results in cellulase production and the conversion of cellulose to glucose, and in fungal biomass production. The soluble, nitrogen rich, fraction of FLW will be fermented in an anaerobic digester, using the residual glucose stream from the aerobic process to produce microbial single cell protein and methane. The fermentation will be controlled by the C/N ratio, volatile dry matter, pH, temperature, retention time, and the microbial culture to maximize SCP production. The two feed products will be evaluated in nutritional studies. An engineering design for a pilot plant capable of handling 1500 kg FLW/day will conclude the research.
SUPPORTED BY: U.S. Dept. of Agriculture.

4.0018
PIPELINE FUEL GAS FROM AN ENVIRONMENTAL CATTLE FEEDLOT
Lizdas DJ, United Technologies Corp., *Broad Brook, Connecticut, 06016,* (AC01-77ET20009)
OBJECTIVE: The objectives of the contract are to design, fabricate, and operate an experimental anaerobic fermentation facility at an environmental cattle feedlot.
APPROACH: The facility will have the capability to process 25 tons per day (dry matter basis) of cattle residues in order to (1) establish information concerning product quantities and values, (2) evaluate process reliability and economics, (3) determine optimum design and operation parameter values for each process stage and unit operation, (4) establish a basis for comparing the process to other means of energy production from cattle feedlot residues, and (5) establish the technological and economic bases for commercial utilization of the process.
PROGRESS: During FY 1980 the anaerobic fermentation system was in operation producing fuel gas which was utilized in the system boiler and in Kaplan's meat packing boiler. A 460-kilowatt grid connected engine generator system has been installed and checked out.
SUPPORTED BY: U.S. Dept. of Energy, Office of Energy Research.

4.0019
MARKET POTENTIALS FOR U.S. FARM PRODUCTS IN DOMESTIC AND FOREIGN MARKETS
Dwoskin PB, National Economic Div., U.S. Dept. of Agriculture, Economics and Statistics Service, *Washington, District of Columbia, 20250,* (NEA-12-108-11-00)
OBJECTIVE: Determine foreign market needs and requirements for food and fiber products to identify U.S. market expansion opportunities. Evaluate market penetration of new or modified highly processed foods and their impacts on marketing and food cost, along with the factors associated with product successes or failures. Assess the size and characteristics of industrial markets and the techno-economic requirements of industrial and uses for agricultural products and byproducts.
APPROACH: A general analytical approach will be employed, utilizing data generated by audit and survey techniques to examine foreign market requirements and impacts of new food forms on food cost. On-site surveys and economic-engineering techniques, including cost-benefit analyses, will be used in analyzing the feasibility of converting agricultural raw materials into fuel, fertilizer, etc.
PROGRESS: Conducted an investigation of the impact of highly processed food products (convenience foods) on food costs. Convenience foods comprise more than a third of total food expenditures. Only 36% of the 162 procesed foods studied had a comparative cost advantage over their non-processed counterpart. However, this does not take into account possible savings in preparation time, etc. Most (80%) of the "new generation" convenience foods were more expensive than their fresh or home-prepared counterpart. Research also has been completed on the U.S. and Japanese fast food industry, foreign market activities of U.S. food manufacturers, and a study of a new hide-to-leather processing method. Major findings were: (1) fast food industry represents a $6.4 billion market for food in the U.S. and a $655 million foreign market potential by 1980; (2) based on 1974-1975 growth rates, Japan's fast food industry will offer an export market potential of almost $.5 billion for food and equipment by 1979; (3) most food processors (8 in 10) are in or plan to get into foreign marketing; and (4) a new hide-to-leather processing method did reduce water pollution, lowered processing costs and provided higher valued leather hides for export markets.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

4.0020
METHANE PRODUCTION FROM AQUATIC PLANTS AND VEGETABLE CROP RESIDUE
Campbell KL, Bagnall LO, Nordstedt RA, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601,* (FLA-AG-02028)
OBJECTIVE: Optimize the production of aquatic plant biomass while maximizing the nutrient removal from waste waters, develop techniques for processing of aquatic plants, evaluate potential availability of vegetable crop residues, and produce methane from aquatic plants and vegetable crop residues.
APPROACH: Controlled greenhouse experiments will be conducted to determine the nutrients limiting the growth of aquatic plants (water hyacinth, pennywort, cattails, and elodea). In the field studies, limiting nutrients will be added to maximize the biomass production while increasing the efficiency of nutrient removal. A survey will be conducted to determine the potential availability of vegetable crop residues for methane production. Techniques for mechanical preprocessing of

aquatic plants for digestion will be developed. Various combinations of aquatic plants and vegetable crop residues will be digested to maximize methane production.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0021
ANIMAL WASTE TREATMENT AND RECYCLING SYSTEMS
Nordstedt RA, Lincoln EP, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601,* (FLA-AG-01649)
OBJECTIVE: Monitor harmful or nuisance residual components and study methods of control. Study performance of treatment systems, and study effect of application rate on soil-crop system.
APPROACH: Coordinated laboratory, pilot scale, and field studies will be initiated to identify potential sources of groundwater pollution from animal producting units, including anaerobic and aerobic lagoons, identify methods of controlling or minimizing groundwater pollution. Evaluate physical, chemical, and biological factors affecting anaerobic and aeribic decomposition of animal wastes. Evaluate the effects of effluents from animal waste handling systems on the soil-plant-groundwater system, and formulate criteria or guidelines for the design and operation of animal waste management systems.
PROGRESS: An anaerobic digestion facility to handle the wastes from the Swine Research Unit at the University was designed. By using a combination of a setting basin and three types of digesters, an attempt will be made to extract as much methane as possible from the waste without extensive modifications to the swine production system. Effluent from the digesters will be used in continuing studies on the renovation of wastewater by overland flow and production of microalgae, the latter also serving to recover waste nitrogen as a protein feed supplement. The overland flow system was renovated and reseeded during the summer and fall. A research-demonstration study was initiated on a commercial dairy to determine effect of aeration on sludge accumulation and lagoon size. Long-term monitoring of commercial poultry flush-recycle systems was continued.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0022
ANIMAL HEALTH AND FOOD SAFETY ASPECTS OF FEEDING ANIMAL WASTE
Shirley RL, Dept. of Animal Science, University of Florida, *Gainesville, Florida, 32601,* (FLA-AL-01931)
OBJECTIVE: Develop methods of processing animal waste feeds that eliminate hazards from pathogenic microorganisms, microbial toxins and internal parasites. Establish the concentration of mineral elements in processed animal wastes and determine the accumulation and depletion of these elements in the tissues or products of the recipient animal.
APPROACH: Mix sodium choloride to whole cattle blood at various levels (0, 6, 9, 12, 15 and 18%) to prevent coagulation and mix treated blood in diets fed steers in a 5 x 5 Latin square metabolism trial. TDN, ME, and N retention will be determined in the diets. Anaplasmosis and leptospirosis tests on the blood of the steers fed the blood diets will be made. Bacterial counts will be made on the diets. Add chlorine compounds to blood treated with NaCl, mix in diets and feed steers as above. Feed steers diets that contain varying levels of the microbial residue after methane generation from cattle manure. The diets will be evaluated for TDN, ME, NE(m) and NE(g) by the California net energy system. The diets and tissues of the steers will be evaluated for potentially toxic materials as Hg, Pb, Cd, Ni, Cu, and Zn. Steaks will be evaluated for overall acceptability.
PROGRESS: (1) Diets that contained 0, 20, 40 and 60% (wet weight basis) of a processed cattle manure reughage from a commercial feedlot were evaluated with steers for metabolizable energy, net energy, feedlot performance, carcass, minerals accumulation in the tissues, and acceptance of steaks for humans. The roughage had low TDN and ME, but the feedlot performance, carcass evaluation data and mineral accumulation in tissues were normal. Acceptance of the meat by panelists was excellent. The manure roughage had only beneficial effects as a feed. (2) Whole cattle blood was mixed with 6, 9, 12, 15 and 18% (W/W) NaCl prior to inclusion of the blood at the level of 13.6% in diets fed steers. The 6% level was sufficient to prevent coagulation. The various levels were tested to determine their effect on TDN, ME, N retention and P balance in a 5 x 5 Latin square metabolism trial. None of these measurements were affected by the salt level. The steers fed the diets were found to be negative to anaplasmosis at the beginning and end of the trial. The whole blood protein was found to be utilized with NaCl.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0023
METHANE PRODUCTION FROM AQUATIC PLANTS AND VEGETABLE CROP RESIDUE
Graetz DA, Dept. of Soil Science, University of Florida, *Gainesville, Florida. 32601,* (FLA-SL-02028)
OBJECTIVE: Optimize the production of aquatic plant biomass while maximizing the nutrient removal from waste waters. Develop techniques for processing of aquatic plants, evaluate potential availability of vegetable crop residues, and produce methane from aquatic plants and vegetable crop residues.
APPROACH: Controlled greenhouse experiments will be conducted to determine the nutrients limiting the growth of aquatic plants (water hyacinth, pennywort, cattails, and elodea). In the field studies, limiting nutrients will be added to maximize the biomass production while increasing the efficeincy of nutrient removal. A survey will be conducted to determine the potential availability of vegetable crop residues for methane production. Techniques for mechanical preprocessing of aquatic plants and vegetable crop residues will be digested to maximize methane production.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0024
CITRUS SPECIALTY PRODUCTS TECHNOLOGY
Braddock RJ, Crandall PG, Reitz HJ, Agricultural Research & Education Center, University of Florida, *Lake Alfred, Florida, 22850,* (FLA-CS-01677)
OBJECTIVE: Develop technology for production of useful and profitable commodities from: refuse from processing plants, component parts of the fruit (peel, rag, pulp, seeds, etc.) and mandarin commodities. The overall benefit from such technology would be to upgrade present commodities into specialty products of greater economic value.
APPROACH: The research will be directed toward problem solving or product/process improvement. Accomplishment will be through the examination of chemical systems in the peel, pulp, rag, seeds, and juice of the various fruits and application of the findings to specific development of products and processing procedures. Research will be done, where required, for each general area of the project in which fundamental information is needed. Once the composition of the fruit is obtained, it will be necessary to develop processing techniques to manufacture various specialty products not now available to the consumer.
PROGRESS: The composition of dietary fibers in dried citrus peels has been determined. Use and benefits of using enzymes in citrus processing has been discussed. Evaluation of dried citrus pulp with the addition of distillers residuals from citrus molasses has been presented. The effect of drying temperature on the quantity and quality of pectin from lemon and lime pomace has been determined. BOD and COD for each component part of a citrus fruit has been determined; as well as, the waste streams emanating from processed fruit. The Brown oil extractor - a new commercial method for production of citrus essential oils in Florida - has been presented to the essential oil industry. Also, the physiochemical properties of orange and grapefruit oils produced commercially on the Brown oil extractor have been determined. The potential production of gasohol from citrus has been investigated. The heat of combustion of dried citrus pulp has been determined as an alternate source of energy. Rootstock has been found to influence the aldehyde and ester content of Valencia orange oil.
SUPPORTED BY: Florida State Government.

4.0025
METHODS AND EQUIPMENT TO IMPROVE DRYING AND CLEANING OF PEANUTS
Blankenship PD, National Peanut Research Lab. U.S. Dept. of Agricluture, Agricultural Research, *Dawson, Georgia, 31742,* (7704-20592-007)
OBJECTIVE: Develop improved methods, techniques and equipment for drying and cleaning of peanuts to maintain quality, reduce energy consumption, improve efficiency, reduce unit cost, and enhance domestic and foreign consumption.
APPROACH: Explore the feasibility of cycling peanut drying to reduce the electrical power requirement during peak-use periods. Evaluate off-cycle periods of 1, 2, 4 and 6 hours for preventing peanut quality deterioration and providing optimum use of energy. Explore the use of timers, limit switches, and shut-off valves for controlling or cycling the drying equipment. Explore the feasibility of using the heat from buring waste (foreign material, peanut hulls, etc.) to supplement the energy requirement for drying peanuts. Develop improved equipment for cleaning peanuts both at the warehouse and the shelling plants.
PROGRESS: Research activity of this unit was limited because of efforts required in planning, designing and supervising the construction of an industry-financed rainfall control plot facility and research precleaning facility. A method for automatic cutoff of full-scale dryers was evaluated. Electronic difficulties were encountered. Automatic cutoff performed satisfactorily for four test series. Temperature profile was measured and milling quality samples were removed from specific locations in drying trailers when peanuts were dried with 35 degrees and 43.3 degrees C air and with 0.28 and 0.56 m (3)/min airflow rates. Shelling of samples and analysis of data will complete a 2-year study to determine if milling quality variations are related to temperature variations. Eight low-cost foreign material extractor systems were evaluated during two harvest seasons. System capacities remained from 27.2 to 45.4 tonnes per hour. System removed many insects and from 4.5 to 18.2 kg of foreign material per tonne of peanuts. Use of these systems should reduce the magnitude of aflatoxin and foreign material problems in storage. Two extractors modified by NPRL engineers provided the best performance.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0026
ENERGY IN WESTERN AGRICULTURE - REQUIREMENTS, ADJUSTMENTS AND ALTERNATIVES
Gopalakrishnan C, Dept. of Agricultural Economics, University of Hawaii, *Honolulu, Hawaii, 96822,* (HAW00455-F)
OBJECTIVE: Estimate current patterns and amounts of energy inputs currently utilized in Western agriculture. Examine and analyze adjustments which might result from changes in prices and supplies of energy resources, and consequent impacts on Western agriculture. Assess contributions of, and prospects for, alternative technologies and policies for dealing with changes in energy availability.
APPROACH: Will gather data and develop coefficients of energy use for major agricultural commodities. Per unit energy requirements for specific commodities and total energy requirements for Hawaii's agriculture will be developed. Impact of changes in energy prices and supplies on the cost structure of enterprise activities will be studied. Potential for alternative energy-saving technologies and policies will be explored.
PROGRESS: Project registered significant progress on a number of fronts. Completed a comprehensive study of the energy requirements, both direct and embodied, of Hawaii's pineapple industry. A report embodying the research findings is nearly completion. Completed a study of the economic feasibility and operational viability of pineapple biomass as an alternate energy source for Hawaii. It was concluded that Maui County could obtain 70% of its energy needs from stack burning of pineapple trash. Two specific accomplishments resulted: (a) a paper reporting on the research findings was accepted for publication in an international journal; (b) a modified version of that paper has been accepted for presentation at the annual meeting of the Western Regional

Science Association, in Monterey, CA, February 1980. A doctoral dissertation is nearing completion. The research involves the use of a statewide linear programming model patterned after a modified version of national models of energy use in agriculture. Primary data for generating coefficients for land, water, energy and transportation for use in the model has been collected for 12 crops from all over the state. These 12 crops account for 98% of the acreage and 94% of the agricultural income in the state. Almost 200 producers were interviewed as part of this effort.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperate Research Office.

4.0027
DESIGN PARAMETERS AND EQUATIONS FOR ANAEROBIC BIOCONVERSION OF ORGANIC WASTES
Yang P, Dept. of Agricultural Engineering, University of Hawaii, *Honolulu, Hawaii, 96822*, (HAW00528-S)
OBJECTIVE: Evaluate the rate constants (based on biological concepts) and equations for the design and prediction of production of methane and degree of stabilization of organic waste in the batch, semi-continuous flow with constant solid recycle systems. Investigate the operational stability of constant sludge recycle system at normal and shock loading conditions.
APPROACH: Laboratory and pilot scale operations will be used for the evaluation of design parameters for batch operations. These parameters will be applied as the design criteria for the development and operation of semi-continuous flow and constant sludge concentration recycled continuous flow systems. Animal wastes, crop residues, and sewage treatment sludge will be used for demonstrating the application of design parameters evaluated from laboratory and pilot scale studies.
PROGRESS: Semi-continuous flow operation with hydraulic retention time of 15 days was conducted for two types of tank anaerobic digester (208 liters, baffled and unbaffled) and a flexible rubber digester (20,000 liters) by using swine waste as substrate. It was found that there is no difference in installation of baffled and unbaffled anaerobic digester for improvement of biogas production. With loading rate of 1 gram TVS per liter of liquid volume per day, 1 liter of biogas per liter of liquid volume per day has been produced. About 1.2 liter of biogas is produced per 1.0 gram of TVS removed. For 20,000-liter flexible gas digester, manure produced by 30-40 pigs (average weight ≤ 150 pounds) were used (slotted floor) as substrate for anaerobic digestion. It was found that 0.5-1.0 liter of biogas is produced per 1 liter of liquid volume per day with 15 days of hydraulic retention time. This unit was installed at the Oshiro farm on Oahu and has been used as the demonstration projects for all interested farmers. Currently, a 2000-pig waste management system has been planned and may be adopted by local farmers. We consider this system to be a low cost, on-farm, effective, environmentally sound operation including a byproduct (methane, protein, water reuse) recovery system. Laboratory batch bench scale study on the kinetic aspect of methane fermentation with and without algal biomass by using swine waste as substrate was conducted.
SUPPORTED BY: Hawaii State Government.

4.0028
DESIGN AND DEVELOPMENT OF RESEARCH EQUIPMENT, DEVICES AND PROCESSES
Moden WL, Dowding EA, Peterson CL, Dept. of Agricultural Engineering, University of Idaho, *Moscow, Idaho, 83843*, (IDA00761)
OBJECTIVE: Design, develop, test, and modify research equipment, devices and processes to solve specific or defined problems not adequately covered by commercial development efforts. Concentrate development efforts in order to increase efficiency and make maximum use of available expertise, technical talent, labor, factilities, and instrumentation.
APPROACH: Scientists in other departments, colleges and outside agencies will be assisted in designing and developing equipment, devices, and processes needed in their research programs.
PROGRESS: A "mechanical ewe" which was developed in 1975 and 1976 for automatic feeding of orphan lambs was modified by using solid state electronic controls and an improved powder weighing system. Initial tests indicate that the reliability of the machine has been greatly improved. The unit will be field tested during the 1980 lambing season. A mechanical wireworm population sampler which was developed in 1976 and 1977 was extensively tested in the Spring and Summer of 1979. It proved to be effective in determining populations of wireworms as well as other subterrainean insects. Occasional losses of insects from the sampler were noted. Minor modifications in the screening system are being made in an effort to reduce these losses. An experimental ethanol still was constructed to test different ethanol recipes using agricultural products and to become familiar with the distillation process. The ethanol produced will be used in testing ethanol consumption in small one-cylinder engines. Limited testing was done on diesel engine performance using sunflower oil and rape seed oil as a fuel.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0029
ALTERNATIVE ENERGY SOURCES FOR AGRICULTURAL PRODUCTION
Smith SM, Peterson CL, Dept. of Agricultural Economics, University of Idaho, *Moscow, Idaho, 83843*, (IDA00787)
OBJECTIVE: Determine and assess available technology for on-farm production of alternative energy and develop means to expand its use and production; develop new practical alternative energy systems for agricultural use; and determine profitability of these systems alone, and within the context of the entire farm enterprise. Initial concentration will be on producing and using alcohol fuel from farm products.
APPROACH: Determine processes most suitable for on-farm use by small scale testing and observation of on-going operations. Monitor on-going operations and evaluate technological improvements to establish economic characteristics of existing and proposed alcohol plants. Examine a range of feedstocks, value of residue as animal feed, and the economics of scale for on-farm, small scale processes. Determine acreages of various crops needed to supply a typical farm s fuel needs, and the economic trade-offs of growing a crop for fuel versus growing as a cash crop. Partial budget, break even, and sensitivity analyses will test the effects of changes in key variables. Analyze and develop production processes to match labor requirements with amounts available on typical farms. Analyze and test alcohol produced in on-farm plants to determine fitness as fuel.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0030
FUEL ALCOHOL FROM BIOMASS
Kobitter RL, Davy McKee Corp., *Chicago, Illinois, 60606*, (GC 5558)
OBJECTIVE: The project objective is a feasibility study for construction and operation of a fuel grade ethanol production facility in South Bend, Indiana. The facility is intended to produce 50 million gallons per year of ethanol and 186 thousand tons per year of distillers dried grains from biomass. Ethanol will be utilized to produce 52.5 million gallons per year of denatured fuel alcohol. The principal raw material used in generating the products is shelled whole corn.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

4.0031
PRODUCE METHANE GAS FROM HOG MANURE
Barney LL, Gilt Edge Farms Inc., *Freeport, Illinois, 61032*, (FG02-80R510210)
OBJECTIVE: This project will demonstrate biogas generation from hog manure and either use the biogas directly, replacing LP, or convert it to electrical energy and recoverable waste heat to produce 80 to 90 percent of the energy needed by a hog production farm. The project will also provide an effective solution to local nuisance odor complaints through stabilization of the majority of the odor-causing components of the hog manure.
SUPPORTED BY: U.S. Dept. of Energy.

4.0032
ENERGY-EFFICIENT ALCOHOL FUEL PRODUCTION
Henry RD, Dept. of Agriculture, Illinois State University, *Normal, Illinois, 61761*, (10962)
OBJECTIVE: The objective is to develop an alcohol fuel plant on the Illinois State University research farm.
APPROACH: The energy required to operate the distilling equipment will be obtained from methane produced from swine manure. The feedstock for the still will be corn. The fuel produced will be utilized by the farm tractors and trucks. The stillage produced will be used to feed dairy and beef cattle on the farm. The manure residue remaining after methane is collected will be used as fertilizer. Some of the equipment for this project will be purchased from commercial firms. The rest will be constructed and assembled by the principle investigator and students. The completed facility will be used as a demonstration facility for area farm operators, students, and other interested persons. The facility will also be utilized for research and instruction.
SUPPORTED BY: U.S. Dept. of Energy.

4.0033
INNOVATIVE FERMENTATION TECHNOLOGY FOR ALCOHOL PRODUCTION
Bothast RJ, Detroy RW, Herman AI, Northern Regional Research Center, U.S. Dept. of Agriculture, Agriculture Research, *Peoria, Illinois, 61604*, (3102-20541-028)
OBJECTIVE: Increase the efficiency of alcohol fermentation through development of new fermentation processes, by selection of microbial strains with greater fermentative ability, and by application of secondary fermentations to better utilize process byproducts.
APPROACH: Develop and evaluate novel fermentation processes for converting glucose to alcohol. Evaluate selected microorganisms for their ability to produce increased levels of fermentative enzymes that can more effectively convert substrates to alcohol. Assess selected microbial strains and new isolates for their ability to produce alcohol under a variety of fermentation parameters, i.e., batch, continuous, cell recycle, and immobilized cells-enzymes. Explore efficient production of alcohol through fermentations of distressed or modified grains. Evaluate methods for further fermentation of proces by-products after recovery of protein.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0034
INCREASED ENERGY EFFICIENCY OF SUBSTRATE PREPARATION FOR ALCOHOL FERMENTATIONS
Detroy RW, Bothast RJ, Herman AI, Northern Regional Research Center, U.S. Dept. of Agriculture, Agriculture Research, *Peoria, Illinois, 61604*, (3102-20541-027)
OBJECTIVE: Develop new chemical and biochemical systems to more efficiently convert plant polysaccharides to fermentable sugars and recover nutrients from fermentation byproducts in order to decrease the energy required for alcohol production.
APPROACH: Investigate new biological, chemical, physical or integrated processes for saccharification of grain starch in contrast to the traditional energy-intensive process. Apply biological and/or chemical procedures to grain and crop residues to render starch and lignocellulosics more amenable to subsequent enzymatic hydrolysis to fermentable sugars. Evaluate biochemical and chemical delignification of lignocellulosic agri-resdues. Select microorganisms capable of preferential biodelignification of residues. Explore a cellulase-catlyzed hydrolysis of lignocellulosics to glucose coupled with direct yeast fermentations. Develop methods for the useful recovery of protein from distiller's grains.
PROGRESS: Various chemical reagents were evaluated as pretreatment agents for delignification and solubilization of straw residues. Anhydrous ammonia and ethylene diamine treated wheat straw with subsequent enzymatic hydrolysis yielded cellulose to sugar conversions of 35 to 60%, respectively. The saccharified materials were further fermented to alcohol. The

oyster mushroom fungus Pleurotus ostreatus was used to biologically delignify wheat straw residues. After a 30 to 50 day fermentation the glucose conversion from the remaining residue cellulose was 324 and 72% respectively. Three basidiomycetous fungi were tested for their abilities to degrade lignocellulosic 1 4C-residues. Lignin- 1 4C-labelled lignocellulose (L★C) and cellulose 1 4C-labelled lignocellulose (LC★) were prepared by feeding maple twigs 1 4C-Phi-alanine and 1 4C-glucose with subsequent preparation and extraction of 1 4C-labelled substrates. The 3 fungi degraded more of the L★C material to CO(2) than the LC★ component. A fourth organism, Cyathus stercoreus degraded the most lignin as judged by our L★C assay. In the hydrolysis of raw corn starch the bacterium Bacillus macerans and the fungus Aspergillus foetidus appear to be the most promising for production of glucose.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0035
CHEMICAL MODIFICATION OF SOYBEAN OIL AND ITS DERIVATIVES
Frankel EN, Pryde EH, Schwab AW, Northern Regional Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Peoria, Illinois, 61604,* (3102-20540-023)
OBJECTIVE: Study modification of soybean oil and its derivatives to provide information needed for expanding and upgrading markets for renewable resources as replacements for petrochemicals in lubricants, nonpolluting paints, and biodegradable plasticizers.
APPROACH: Prepare prepolymers from soybean oil that contain heteroatoms (nitrogen, sulfur, halogens) and metals; react them with dibasic acids, hydroxyamines, or other intermediates that contain reactive groups for waterbased and other nonpolluting coatings. Prepare and evaluate sulfur derivatives of soybean oil as sperm oil replacements. Prepare germinal and other hydroxymethyl compounds from soy fatty acid oxo derivatives; convert these derivatives to biodegradable plasticizers that have low migration, toxicity, extractability, improved low-temperature flexibility and light stability.
PROGRESS: New types of solventless, baked-coating materials from fatty-derived starting materials were investigated, one type from fatty dicarboxylic acids and a second type from a naturally epoxidized seed oil, Vernonia pauciflora. Preliminary tests indicated both types gave metal coatings with excellent flexibility and adhesion. Octadecyl tetrasulfide was synthesized and characterized by X-ray diffraction and mass, nuclear magnetic resonance, and Raman spectroscopy as a model compound for our investigations on sulfurized oils. A variety of commercially available silanes were evaluated for hydrosilylation of unsaturated fatty acids. Methyl bis (trimethylsiloxy)silane was particularly effective. Of seventeen homogeneous organometallic complex catalysts evaluated for the hydrosilylation reaction, eight catalysts warrant further study. Two formulations incorporating aqueous alcohol into diesel oil were developed and are being evaluated at the University of Illinois. The formulations remained homogeneous to at least -4 degrees F (-20 degrees C). Use of aqueous in place of anhydrous alcohol will effect considerable savings in processing costs.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research

4.0036
ENZYMATIC CONVERSION OF CELLULOSE TO SUGARS FOR ALCOHOL FERMENTATIONS
Griffin HL, Krull LH, Northern Regional Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Peoria, Illinois, 61604,* (3102-20541-030)
OBJECTIVE: Characterize factors that limit efficiency (rate and extent) of enzymatic conversion of cellulosics by "complete" cellulase systems to sugars for alcohol fermentations.
APPROACH: Emphasize factors that limit cellulolysis: Substrate structure, enzyme reaction mechanism, and inhibition by substrate, cellulolytic products, and associated compounds such as lignin. Employ physical and chemical techniques to obtain kinetic data about the nature and effect of each of these factors on conversion efficiency. Base kinetic data on compositional and chromatographid (GLC and HPLC) studies of sugars, cellulosics, and lignin present in the substrates as well as of cellulolytic products and residues. Structural changes occurring during cellulolysis or pretreatment of substrates will be monitored by electron microscopy. These investigations will be integrated with and guided by work extending previous results that indicate the enzyme's maximum potential efficiency is limited by a cofactor regulated mechanism. Chemical and physical techniques will be developed to isolate and stabilize enzyme components for compositional, physical, and enzymatic characterization.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0037
ENERGY-SAVING METHODS FOR RECOVERY OF USABLE PROTEIN FROM ALCOHOL OR METHANE FERMENTATION MEDIA
Wall JS, Wu YV, Nielsen HC, Northern Regional Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Peoria, Illinois, 61604,* (3102-20541-029)
OBJECTIVE: Develop physical and chemical means of concentrating and separating protein and other valuable nutrients from alcohol or methane fermentation stillage and grain processing waters that will reduce processing energy requirements and produce products of improved nutritional value.
APPROACH: Investigate grain alcohol fermentation solubles and grains, fluids from fermentation of animal wastes to yield methane, and gluten and steeping liquors from corn wet-milling and by-products. Methods of removing protein and other nitrogenous substances include reverse osmosis, plant-scale electrophoresis, ion exchange precipitation as complexes with charged macromolecules, and thermal denaturation. Examine products and fractions for proximate analysis, amino acids, and nucleic acids. Separate soluble fractions by gel filtration, and determine physical properties. Investigate intrements with enzymes or microbes. Extract distillers grains with dilute alkali or alcohol solutions, and investigate use of extraacted material. Cooperate with Meat Animal Research Center, Clay Center, Nebraska, who will conduct methane fermentation and test some experimental feed products.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0038
RESEARCH ON ANAEROBIC FERMENTATION OF BEEF CATTLE AND CROP RESIDUALS
Jantzen D, U.S. Meat Animal Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Peoria, Illinois, 61615,* (DB 9 8372 01)
OBJECTIVE: The objective is to extend previous study and evaluate potential of 2-stage digestion system in order to attain higher methane production rates. Tasks include: (1) optimization of alkaline pretreatment process to break down solid fraction of feed; (2) development of first stage of fermentation process where sugars and fatty acid are produced; (3) evaluation of kinetics of methane fermentation, and (4) assessment of operation of entire pilot scale system and its economic potential.
SUPPORTED BY: U.S. Dept. of Energy.

4.0039
FUEL FROM AGRICULTURAL BIOMASS: IMPLICATIONS FOR FARM STRUCTURE AND SIZE
Braden JB, Sonka ST, Swanson ER, Dept. of Agricultural Economics, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-05-0302)
OBJECTIVE: To asses impacts of fuel production from agricultural wastes on farm size and uses of agricultural land. The primary focus is on farm operations in Illinois. Short-term objectives include a survey of literature short-term objectives include a survey of literature and assessments of data needs and appropriate analytical methods. Mid-term goals include data collection, preliminary analyses, and preparation of interim reports.
APPROACH: Initial efforts will be to review literature on biomass conversion. Specialists in other departments of the College and elsewhere will be consulted on technological options, and the costs, outputs, and commercial prospects for each. Viable options will be cast as scenarios. Farm management models employing data from Illinois farm records will be used to determine shifts in farm input and management practices for each scenario. Conclusions will be drawn for each scenario regarding changes in management practices affecting the farm size and uses of agricultural lands.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0040
ELECTROCHEMICAL CONVERSION OF BIOMASS INTO PROTEIN AND HYDROGEN
Day DL, Steinberg MP, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-10-0376)
OBJECTIVE: Investigate technical and economic feasibilities of electrochemical oxidation of biomass to produce feed protein and by-product hydrogen, safe handling and storage of hydrogen, and hydrogen-oxygen fuel cell production of d.c. electricity.
APPROACH: Liquid swine manure will initally be the biomass to be converted in bench scale electrochemical cells. Aerobic bacateria will utilize oxygen as it is produced at the anodes and hydrogen, and energy source, will be produced and collected at the cathodes. The hydrogen will be utilized in a fuel cell to produce d.c. electricity to supplement operation of the electrochemical cell. Technicl operational parameters will be studied to achieve optimum growth of single cell protein and production of hydrogen. Conditions promoting additional production of hydrogen from biomass by anaerobic bacteria will also be studied.
PROGRESS: Electrical efficiencies have been better than expected, approaching 100%. In the laboratory bench scale phase of producing protein and hydrogen by electrochemical conversion of liquid manure and the hydrogen purity as collected has been essentially 100%. The concept involves integration of two processes in the same vessel: one is electrolysis of water into hydrogen and oxygen and the other is aerobic conversion of waste organic matter and inorganic nitrogen into cells high in protein that can be used in animal feed rations. Each process should be more efficient due to the simultaneous presence of the other. Thus the multiplication of aerobic bacteria in an aqueous medium will reduce the oxidation-reduction potential of the medium. This should serve to depolorize the oxygen anode and reduce the voltage required. Satisfactory electrode materials have been found and the sandwich arrangement of electrodes within the cell has been successful. The system, however, is very sensitive and several runs have had to be terminated because of yet unknown causes of failures to produce hydrogen. Methods of storage and use of hydrogen are also being studied. Utilization in fuel cells or Stirling cycle engine-generators look promising.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0041
HYDROGEN AND PROTEIN BY OFF-PEAK DEPOLARIZED ELECTROLYSIS BIOMASS
Day DL, Steinberg MP, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-10-0674)
OBJECTIVE: Test a new low odor method of producing hydrogen fuel and feed protein from biomass using a system combining electrolysis of water to hydrogen and oxygen and conversion of organic matter and inorganic nitrogen into microbial cells high in protein.
APPROACH: We will determine the effects of physical, chemical, and biological parameters on the integrated process to optimize hydrogen and protein production. Several electrochemical fermenters will be operated simultaneously using such biomass as livestock manure and other recoverable resources. Off-peak electricity can be utilized to free hydrogen for other fuel uses or it can be used to produce process electricity.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0042
EMPIRICAL ENERGY AND ECONOMIC BALANCES FOR ETHANOL AND GASOHOL PRODUCTION
Dovring F, Herendeen RA, Dept. of Agricultural Economics, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-05-0333)
OBJECTIVE: Obtain energy balance and economic costs for operating ethanol or gasohol plants. Compare small and large operations regarding their potential for using renewable energy inputs.
APPROACH: Interviews at operating gasohol and ethanol producing plants will be used to obtain detailed data on mass and energy balance. Care will be taken to obtain steady-state requirements or, if applicable, the additional energy and materials requirements for sporadic operation. The techniques used will be akin to standard engineering process analysis. If renewable inputs (e.g., stover) are used, process analysis will also be applied to the energy requirements for providing them. Similar techniques will be used to determine economic inputs and revenues, with labor inputs obtained by interview and direct observation. Analysis will combine energy process analysis, conventional economic analysis (budgeting), and reference to the literature on the feasibility of crop residue removal (or the energy costs of such removal).
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0043
REDUCING DEPENDENCE OF TRACTORS ON PETROLEUM FUELS
Goering CE, Hunt DR, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-10-0335)
OBJECTIVE: Increase fuel use efficiency of internal combustion engines, develop improved methods for burning ethanol in tractor engines, investigate burning of vegetable oils in diesel engines, investigate uncoventional engines for burning solid, biomass fuels.
APPROACH: In laboratory, explore techniques for increasing fuel use efficiency, dual-fuel diesel engines with ethanol and diesel fuel using blends and/or fumigation approaches. Use additives and/or engine modifications to increase percent of energy supplied by ethanol. Measure chemical and physical properties of vegetable oils and their performance as fuel in diesel engines. Investigate use of Stirling cycle engine in burning solid, biomass fuels. Design solid fuel combustors for Stirling engines.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0044
TECHNOLOGY OF ALCOHOL MANUFACTURE ON THE FARM
Hunt DR, Rodda ED, Steinberg MP, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-10-0316)
OBJECTIVE: Design and build a small scale alcohol production system based on corn as a feedstock. Study operation requirements to establish guidelines for farm scale equipment. Products made will be tested in on-going fuel utilization studies in the department. Investigate process alternatives to improve the energy efficiency. Develop materials handling methods for solids, slurries, and distillation products. Investigate a farm scale system to use sweet sorghum as a feedstock.
APPROACH: An alcohol production unit will be constructed in the laboratory to develop a working system which will then be studied for operation requirements and modified for further process studies.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0045
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S-NUTRITIVE VALUE OF OXIDATION DITCH RESIDUES
Jensen AH, Dept. of Animal Science, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-20-0395)
OBJECTIVE: Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses with consideration of the human, animal, and plant health factors.
APPROACH: Aerobically-processed wastes will be fed to supplement the regular diet of swine.
PROGRESS: Evaluation of oxidation ditch mixed liquor (ODML) as a source of nutriture for swine was continued. Preliminary trials to evaluate ODML as a source of supplemental calcium (Ca) and phosphorus (P) indicated that dry, fat-free bone weights of pigs receiving ODML and no supplemental Ca and P were intermediate to those of pigs receiving the supplemented diet, regardless of water source, and those of pigs receiving tap water and no supplemental Ca and P. ODML as a potential source of supplemental Ca and P was further evaluated using pigs averaging 61 kg which had access to either tap water or ODML as water source. The 14% CP corn: soybean meal diet contained either 0, .16, .32 or .48% supplemental Ca and, respectively, 0, .03, .06 or .09% supplemental P. Gain, feed intake and gain/feed values indicated that pig performance was not affected by source of drinking water, level of supplemental Ca and P or their interaction. Bone samples from these pigs are currently being analyzed to determine any effects on bone growth, mineral composition or strength due to water source, level of supplemental Ca and P or their interaction. Average assay values of ODML during this trial were 597 ppm nitrates, 26616 C.O.D. 2.82% total solids, 24 degrees C and pH8.0.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0046
STUDY OF BIOLOGICAL CONVERSION OF BIOMASS TO METHANE
Jantzen D, Dept. of Civil Engineering, University of Illinois, *Urbana, Illinois, 61801,* (XB 0 8357 0101)
OBJECTIVE: The objective of this study is to test and develop anaerobic digestion systems for the economic and energy efficient conversion of crop residues to methane. Biodegradability of 71% has been demonstrated for corn stover, and an economic analysis indicates that this process could produce methane for about $10/M Btu.
APPROACH: The approach involves: (1) determining the thermochemical pretreatment conditions for corn stover that yields the maximum increase in biodegradability when used as a substrate for anaerobic digestion to methane; (2) determining the first order rate constant and the biodegradability of the pretreated stover at a 60 degrees C fermentation temperature; (3) evaluating the dewatering characteristics of the resultant slurries by both filtration and centrifugation; and (4) estimating the processing costs for the production of fuel gas from this system.
SUPPORTED BY: U.S. Dept. of Energy.

4.0047
MICROBIOLOGY OF THE THERMOPHILIC METHANOGENESIS IN CATTLE WASTE
Bryant MP, Dept. of Dairy Science, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-35-0331)
OBJECTIVE: Obtain fundamental information on the microbial and biochemical ecology of the bacterial system involved in production of methane from cattle waste under thermophilic conditions (60 degrees C) so that detailed information will be available concerning the pathways of metabolism, major kinds of bacteria responsible for specific metabolic reactions and metabolic and nutritional interactions involved in efficient methanogenesis.
APPROACH: Isolate and characterize the major groups of bacteria involved in rapid and efficient degradation of organic matter of cattle waste to methane and CO(2) under anaerobic conditions at 60 degrees C. Major emphasis will be placed on bacteria responsible for fiber, protein, and lipid degradation, those involved in degrading intermediates such as fatty acids to acetate, and species directly producing methane from acetate and hydrogen and determination of features of importance to establishment of their specific functions in the ecosystem.
PROGRESS: Stirred, benchtop fermentors with 3-litre working volume and fed on a semi-continuous basis with waste obtained from dairy cattle fed a high concentrate, finished diet were used to study the quantitative contribution of fatty acids to methanogenesis. In the thermophilic digestors (60 degrees C, 6% volatile solids and 10-day retention time) the turnover rate of acetate varied from a basal level of 0.034-0.045 to a peak of 0.114-0.138 mM/min 2-5 h after feeding. The percentage of CH(4) formed via the methyl group of acetate was 72-75% at basal level but increased to 85-87% at peak acetate turnover. Propionate and butyrate turnover ranged from 0.003-0.015 mM/min over a 24 h period and accounted for 6-25% of the CH(4) produced. Mesophilic methane production at 40 degrees C was initiated by bacteria present in the waste. After steady state conditions were reached (5-volume turnovers) CH(4) production was 30% less in the mesophilic than the thermophilic digestor fed the same substrate under identical loading conditions. Turnover rates for acetate propionate and butyrate were correspondingly lower.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0048
SOLIDS-LIQUID SEPARATION OF ANIMAL WASTE
Spahr SL, Day DL, Vanderholm DH, Dept. of Dairy Science, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-35-0353)
OBJECTIVE: Evaluate the liquid and the solid components resulting from mechanical separation of dairy manure for their on-farm use via refeeding, use bedding, generation of methane, and use as fertilizer.
APPROACH: The washed, fibrous portion will be evaluated via feeding trials as a feed for replacement heifers. Effects of ensiling and the addition of supplements at various levels will be determined. The fiber will be evaluated for bedding in free stalls with investigations designed to determine the microbiological safety of this practice relative to mastitis. The liquid portion will be recovered and evaluated for recycling as a pre-separation diluent in place of fresh water, as a source for on-farm generation of methane, and as a crop fertilizer.
PROGRESS: A series of trials was conducted with a perforated-roller type solids-liquid separator to characterize the separation characteristics of the unit with dairy waste. High solids content (7-8%) of the unseparated slurry was associated with greater fiber production, higher dry matter percentage in the separated fiber, and greater efficiency of separation for volatile solids, acid detergent fiber, chemical oxygen demand and dry matter than was found with more diluted slurry (3.5 to 5% DM). Nitrogen was partitioned mainly into the liquid effluent; about 9% of the slurry nitrogen VS., 22% of the dry matter was found in the fiber fraction Nitrogen content of the dry matter in fiber was. 93% VS. 2.45 for unseparated slurry. Washing of fiber solids prior to processing in the third and fourth set of rollers resulted in lower dry matter content of the separated fiber and a greater dilution of the constituents in the effluent, but had no effect on the proportion of dissolved solids removed or on the apparent cleanness of the fiber solids.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0049
PRODUCTION OF ETHYL ALCOHOL FROM A BY-PRODUCT OF CORN STORAGE
Hodel GE, Performing Institution Not Reported
OBJECTIVE: The feasibility of producing ethyl alcohol from corn screenings will be determined. The costs will be compared to those of corn.
SUPPORTED BY: U.S. Dept. of Energy.

4.0050
POLICY ANALYSIS OF STRATEGIES AND PROGRAMS ON DIVERSE FARM FIRMS IN THE CORN BELT
Doering OC, Dept. of Agricultural Economics, Purdue University, *Lafayette, Indiana, 47907,* (IND045049)
OBJECTIVE: Gain an understanding of the substitutability of resources in agricultural production for different types and sizes of farms. Assist the development of alternative strategies to adjust to energy and other resource shortages and assess the impact of different resource and farm commodity policies on diverse farm firms.
APPROACH: Multi-disciplinary work on resource use, substitution, and physical input/output rela-

tionships in agricultural production. Improve and further utilize the Purdue crop/energy simulation model and integrate this with the economic and farm management models such as Purdue B-9 to look at policy impacts and resource shifts in terms of the economics of different farm firms.
PROGRESS: Most of the work during this period was the examination of alternative technologies that would allow agricultural producers to substitute management and other resources for energy. An analysis was completed on the economic and systems feasibility of utilizing corn cobs to produce a low BTU gas for drying grain. This concluded that such systems are economic and could be available at modest capital cost. In addition, analysis was begun to investigate higher capital cost alternatives like heat-pump grain drying, determine the total cost and systems feasibility of such systems, and also investigate whether high capital cost systems give special advantage to large or high income farmers in adopting energy saving technology. Work is also now underway on the potential contribution of the traditional agricultural sector to energy production in the form of biomass. This involves an examination of the economic and systems trade offs in both production and processing of such materials. Work has been completed for the Office of Technology Assessment on land availability for biomass production. Further work is underway examining farm sector trade offs between energy coop and by-product production for Corn Belt crops.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0051
ANALYSIS OF FOOD AND AGRICULTURAL POLICY ALTERNATIVES
Sharples JA, Dept. of Agricultural Economics. Purdue University, *West Lafayette, Indiana, 47907,* (IND045046)
OBJECTIVE: Develop research tools that can be used to evaluate the impact of food and farm policies. Estimate impact on markets, income, and government costs of alternative commercial farm and trade policies.
APPROACH: Regression, math programming, and simulation techniques will be used to build single and multi-commodity models. These will use secondary data from USDA, U.S.Census, and other sources.
PROGRESS: An analysis was made of the impact of alternative levels of gasohol production on the corn and soybean markets. Results show that the annual production of four to eight billion liters of alcohol from corn would not have a major impact on the corn and bean market. There would be a small increase in the corn price and a decrease in the soybean price (due to increased supplies of distillers dried grain). Annual production of 15 billion liters of alcohol, however, would have an impact not acceptable in the current U.S. food and agricultural policy context. An alternative farmer reserve for grains was also analyzed. The alternatives consisted of a direct storage subsidy to producers who held grain over into the following crop year. Producers could sell the grain any time they chose. Preliminary results indicated that this alternative reserve might better achieve policy objectives than the actual farmer reserve. Further analysis of the alternative is needed. Two modeling objectives were also achieved. A technique was developed for obtaining a numerical solution of a single-commodity, multi-market, equilibrium trade problem involving nonlinear supply and demand functions and trade distortions. Also, a stochastic simulation model of the corn and soybean markets (called FEEDSIM) was constructed. This model is specifically designed to analyze agricultural commodity program alternatives.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0052
FUELS FROM BIOMASS: ENERGY EFFICIENT PRODUCTION OF ANHYDROUS ALCOHOL
Ladisch MR, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (IND046064)
OBJECTIVE: A new approach is under study whereby the energy needed to produce anhydrous from dilute alcohol is 1/10 of the energy contained in the final product. This is possible by combining partial distillation with chemical drying agents. Drying agents including metal oxides and hydroxides, sulfate salts and acids, cellulose, starch, and cellulosic residues will be studied with respect to equilibria, capacities, optimum conditions for use and regeneration, durability, and cost. The most suitable will be integrated into a bench-scale process. Successful development will help to give a positive energy balance for production of alcohol from plant matter.
APPROACH: Dehydrating agent effectiveness will be studied with respect to temperature, vapor rate and starling alcohol concentration. Mass and energy balances will be calculated for the dehydration step alone and for dehydration combined with partial distillation. Chemical analysis will be based on gas and liquid chromatography and Karl-fischer water analysis. Runs will be made with both reagent-grade ethanol as well as fermentation broths.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0053
ENGINEERING STUDIES ON A NEW WAY TO DEHYDRATE ETHYL ALCOHOL WITH CORN
Ladisch MR, Hong J, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (IND046046-C)
OBJECTIVE: Develop reliable engineering correlations for designing farm and industrial scale alcohol dehydration units utilizing corn, starch, or similar adsorbents.
APPROACH: Obtain fundamental adsorption data in the laboratory and develop theoretical correlations. Use these correlations to design, build, and test pilot unit.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0054
SAFETY AND PERFORMANCE OF TRACTORS AND MACHINERY
Liljedahl JB, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (IND046018)
OBJECTIVE: Study methods of reducing accidents; study methods of reducing noise from tractors and machinery; study methods of improving tractor control; predict dynamic behavior of tractors, and improve traction on tractors.
APPROACH: Use surveys, experimental studies, use of tractor ride simulator, develop and test mathematical models, and use simulitude and the agri-engineering soil bin to test methods of improving traction.
PROGRESS: The research work of two graduate students was completed. A study of traction on sandy soils by Fathi Farah was completed in August 1979. The study showed, except for a very dry soil conditions, that tire tread design had little effect on the drawbar pull. There was a slight advantage in pull for tires with a diamond tread and for tires with no lugs. A study of traction in muddy soils was completed by Tony Ozogu in December 1979. The study shows that traction in flooded rice soils could be improved by 300% if conventional tractor tires were equipped with paddles projecting beyond the tire a distance 0.3 times the tire width and to the side a distance equal to the tire width. A preliminary study was made of a method of salvaging corn cobs for energy. The study was very encouraging in that the cob saver attachment salvaged 78% of the cobs which were about 90% pure cobs.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0055
DEVELOPMENT OF METHODS AND EQUIPMENT FOR SALVAGING CORN COBS FOR ENERGY
Liljedahl JB, Doering OC, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (IND046018-B)
OBJECTIVE: Develop a cob saving attachment for a corn combine. Study methods of transporting cobs, study methods of storing corn cobs. Estimate the cost of salvaging, transporting, and storing cobs.
APPROACH: A prototype of a combine cob saver was designed, constructed, and partly tested during the fall of 1979. This machine gave encouraging results but needs much improvement. The emphasis will be placed on redesigning and testing an improved cob saver. We will briefly examine transporting of corn cobs in a self-unloading forage wagon which appears to be the best equipment. Any modifications that must be made will be reported. Three types of storage will be investigated for energy loss and for spontaneous combustion. We will store cobs in piles, in corn cribs with roofs and in corn cribs without roofs. Costs of salvaging, transporting, and storing corn cobs will be determined by using conventional machinery cost methods.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0056
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
Nye JC, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (IN-D046033A)
OBJECTIVE: Develop optimal animal manure management systems to meet evolving environmental and economic requirements; investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production, and other potential uses.
APPROACH: Complete flushing systems in conjunction with one, two, and three-stage lagoons are to be tried for swine production systems. Observations are to be made on a run-off storage and irrigation system for a dairy cow operation. Responses of crops to various levels of application of swine and dairy cattle manure are to be observed. The synthesis of wastes by single cell bacteria is to be continued. Methane production research is to be continued.
PROGRESS: The rate of gas production from anaerobically stored swine manure was evaluated. In the first study gas production during batch storage of swine manure at two solids concentrations and 3 pH levels were compared. It was found that more gas was produced at higher solids concentrations and with no pH control than was observed when the pH was held at 6 or 8. The highest rate of gas production was 6.5 x 10 (- 5) moles per hour per kilogram of manure. During the 60 days storage approximately 30% of the volatile solids were destroyed. In the second study a semibatch process was evaluated. Manure was added at two loading rates. These loading rates were 1.5 and 3 kilograms of volatile solids per day per cubic meter. The highest total gas release was 7.4 x 10 - 4 moles per hour per kilogram of manure. During these studies the acid soluble and base soluble gases were selectively removed to determine three gas production rates. The non-acid soluble gases such as ammonia and the volatile amines was much much less than the non-base soluble gases which would include carbon dioxide. This would indicate that the major gas produced during anaerobic storage of manure was carbon dioxide. In the semibatch studies on set of samples was initially seeded with sewage sludge from the West Lafayette Sewage Treatment Plant. This sewage sludge provided a culture of anaerobic microorganisms. As a result the gas production from these samples was much greater than the samples from the other storage that were unseeded.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0057
EQUIPMENT FOR BIOMASS ENERGY CONVERSION
Paert RM, Richey CB, Barrett JR, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (3090-20191-002A)
OBJECTIVE: Investigate conversion of biomass, including baled forage, corn cobs, corn stover, and other agricultural crop residues into heat or combustible gas. Develop prototype equipment for testing operational parameters for converting different residues, and determine workable, optimal designs of equipment for on-farm use as influenced by the physical properties of the residues. Determine Btu contents of the products converted, by-products formed as exhausts, and residues remaining after conversion.
APPROACH: Review related published and on-

going research, design equipment compatible with automatic data acquisition to monitor heat and mass flows, construct basic equipment of maximum 1,000, 000 Btu per hour capacity for producing direct heat, or for use in combination with a gasifier or pyrolyzer which produces combustible gas that is burned for direct heat. Test the prototype equipment in actual conversion evaluations.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0058
ETHANOL FROM CORN SILAGE
Mehlberg RL, Lab. of Renewable Resources Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (FG02-80R510224)
OBJECTIVE: The goal of this project is the construction and demonstration of a small scale (6,000gallons per year) ethanol process using corn silage as feed and corn stover as fuel.
APPROACH: Blueprints and performance data will be the final product. This low technology process has been made possible by two new developments at Purdue's Laboratory of Renewable Resources Engineering (LORRE): low technology hydrolysis of the hemicellulose portion of the fiber, and adaptation of the simple yeast fermentation to produce ethanol from the hemicellulose sugar, xylose, as well as from the grain starch. In this process, 75% more ethanol can be produced from an acre of land because xylose from the hemicellulose is fermented as well as starch derived glucose from the grain. Energy inputs to this silage ethanol process are 14 to 25 MBtu/gallon lower than a grain alcohol process. Farming inputs (diesel fuel, ammonia, pesticides) per gallon of alcohol are lower because of the higher ethanol yield per acre. Grain drying is eliminated and a low energy hydrolysis (or cooking) is used.
SUPPORTED BY: U.S. Dept. of Energy.

4.0059
ETHANOL PRODUCTION FROM RENEWABLE RESOURCE AND WASTE PRODUCTS THROUGH THE CONVERSION OF AN UNUSED MINT DISTILLERY
Hilger JH, Performing Institution Not Reported.
OBJECTIVE: The objective is to produce ethanol through the conversion of an unused mint distillery to an alcohol plant using renewable resources such as grain, potatoes, sugar beets, sugar cane, melons, etc. This would include waste products that come from the food industry such as grocery stores, wholesale houses, elevators, etc. This would also utilize the waste products of the consumers' homes. Utilization of this nature would lessen our dependence on non-renewable energy sources.
SUPPORTED BY: U.S. Dept. of Energy.

4.0060
SMALL CONTINUOUS ETHANOL PLANT FOR FARMS
Sweany RS, Performing Institution Not Reported.
OBJECTIVE: This project is the building and operation of a small (3 gallon per hour, 180 proof) continuous ethanol plant for farms. Almost all farm plants in use today are batchwise plants. Batchwise plants are large relative to their output and are difficult to make efficient. This project will seek to make an efficient, continuous production plant that can be easily built by farmer expertise.
SUPPORTED BY: U.S. Dept. of Energy.

4.0061
DEVELOPMENT OF BIO-MASS SYSTEMS FOR DRYING CORN
Buchele WF, Marley SJ, Dept. of Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (IOW02325)
OBJECTIVE: Design, construct, develop, test and promote the use of a cornstalk fueled furnace for grain drying bins. Both direct and heat exchanger furnaces will be developed.
APPROACH: Combustion engineering and grain drying principles will be combined to produce an economical design of a cornstalk fueled furnace. Controls will be developed to operate the furnace and control the hot air supply to the grain bin.
PROGRESS: A 4 1/2 million Btu current, concentric vortex biomass furnance for generating hot air was designed, fabricated and tested while burning corncobs. Slag, created during combustion, flowed downward through the opening of the firebrick grate into the ash box where it was easily removed. Based on the combustion tests and fabrication experiences, a second generation furnance which will be easier and cheaper to build and operate will be designed, constructed and tested during 1980. Instruments and equipment for automatically controlling the furnace will be attached to the furnace. A steam generating boiler for operating an ethanol distillery will be designed and attached to the furnace.
SUPPORTED BY: Iowa State Government.

4.0062
AN INTEGRATED FARM ENERGY SUPPLY SYSTEM FOR THE IOWA FARM
Buchele WF, Marley SJ, Smith RJ, Dept. of Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (IOW02312)
OBJECTIVE: Develop and promote the use of farm size distilleries in an integrated energy system for the Iowa farm. Develop and promote the use of corn-cob gasifiers on tractors in an integrated energy system for the Iowa farm.
APPROACH: Chemical and engineering analysis will be used to disign, construct and develop a corn-fed farm size distillery and a corncob producer gas generator.
The goal of this project is the construction and demonstration of a small scale (6,000gallons per year) ethanol process using corn silage as feed and corn stover as fuel. Blueprints and performance data will be the final product. This low technology process has been made possible by two new developments at Purdue's Laboratory of Renewable Resources Engineering (LORRE): low technology hydrolysis of the hemicellulose portion of the fiber, and adaptation of the simple yeast fermentation to produce ethanol from the hemicellueter, 17 foot distillation column equipped with 22 (down comers) sieve plates (3/16 inch diameter on 5/16 inch spacing). Power and fuel efficiency curves were drawn from data collected when the various proof ethanol fuels were burned in a 9 to 1 compression ratio Otto Cycle engine. Excellent performance was obtained with 180 and 190 proof alcohol.
SUPPORTED BY: Iowa State Government.

4.0063
CONTINUOUS ON-FARM CORN-ALCOHOL PRODUCTION AT 12 GPD: ENERGY AND MANAGEMENT NEEDS
Buchele WF, Smith RJ, Marley SJ, Dept. of Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (IOW02451)
OBJECTIVE: Continuous enzymatic saccharification of corn using low-pressure steam. Fermentation strategies for continuous production of beer. Develop a 100 mm diameter instrumented distillatiion column with low-cost automatic controls. Run the whole system and measure energy flows and optimize energy-in to energy-out with respect to fuel water content. Operate column under vacuum.
APPROACH: Heat to 100 degrees C by steam, pump to 300kPa. Flash cool to low pressure to encourage starch disruption. Multiple batch and continuous fermentation, problem of contamination, copper distillation column in flanged modules, easy change of internal parts, and solenoid valve control will be examined.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0064
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
Smith RJ, Hammond EG, Vetter RL, Dept. of Agricultural Engineering, Iowa State University, *Ames, Iowa, 50010,* (IOW02126)
OBJECTIVE: Conceptualize, develop, analyze, and optimize animal manure management systems with least cost and energy requirements for pollution control compatible with changing socio-politico-economic patterns. Specific objectives are to develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein. Characterize atmospheric contaminants and develop abatement methods to eliminate the contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production, and other potential uses with consideration of the human, animal, and plant health factors.
APPROACH: Pilot scale work on surface aeration of lagoons will be scaled up for a full size lagoon. Results obtained from a 100 gallon existing anaerobic digester will be extended to a pilot scale unit for several beef animals. Cooperative work with animal scientists will determine the feasibility of using digester effluent to produce stover silage. Observer panels will correlate odors from various livestock production systems with chemical odor standards.
PROGRESS: 1. Four 1 L model digesters were constructed; gas production was determined by pressure change over 24 hours. Ground (ball mill) vs. unground beef manure was digested. No significant differences in performance were detected. Grinding with NaOH (7.5% dry-weight basis, neutralized before digestion) showed improvement in gas production. 2. A PET 2001 microcomputer and an Omega 410 electronic thermometer were bought, and a data-acquisition system for a full-scale anaerobic digester is being constructed. Thirty-two channels of thermocouples and 32 channels of analogue data will be implemented. 3. An influent-to-effluent heat exchanger is being constructed for a 60-head beef-manure digester. The liquids will pass countercurrently through a tank, 75 mm x 910 mm x 1220 mm, and transfer heat through two 910 mm x 1220 mm common walls of 0.8 mm stainless steel (there are three adjacent tanks). Heat transfer will be augmented with mechanical agitators; these also are intended to prevent solids deposition in the tanks.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0065
BEEF PRODUCTION USING MANURE AND CROP RESIDUES FOR MAJOR FEED SOURCES AND METHANE PRODUCTION
Smith RJ, Burroughs WE, Dept. of Animal Science, Iowa State University, *Ames, Iowa, 50010,* (IOW02179)
OBJECTIVE: Evaluate a beef cow-calf nutrition and management program over a 3-year period which utilizes crop residues and excreta from confined feedlot cattle as the major feed sources. Evaluate the use of crop residues and animal wastes in growing rations for calves and yearlings compared with conventional feedstuffs, primarily corn silage. Compare the composition, ensiling characteristics, and nutritional value of animal wastes collected and processed by the methods: direct scrapings from feedlot floor; solids from a flush system; slurry from an anaerobic digester. Evaluate on a year-round basis, the effects of extreme environmental changes experienced in the upper Midwest on the composition and ensiling characteristics of feedlot cattle wastes. Develop complete engineering plans and specifications for a heated (95 degrees F), mixed digester that will process the manure from 30 beef animals. Monitor digester operations. Examine certain physical and chemical properties of the digested effluent. Develop a scraped surface heat changer for recovering heat from the digester effluent and transferring this heat to the influent manure slurry.
APPROACH: Use 120-head cow herd and calves for 3-year study of beef production with the developed feed resources. Supporting laboratory research. Phase development of waste handling systems and characterization of wastes. Scale up of anaerobic digester develop concepts.
PROGRESS: Construction of a system of manure handling and digestion for 60 cattle continued. Four 200 mm syphon flush tanks were constructed to flush the manure from under slats. The discharge of 100 L/s provided uniform flow at 40 mm depth across a l.l m channel. A 4218 Slurrystore, donated by A. O. Smith Harvestore, has been erected by the digester. This tank will be used for effluent storage and has provision for recycling liquid or solids back to the digester. A two-speed

turbine mixer has been designed and partly constructed. Vigorous mixing at 60 rpm will be provided once daily and intermittent stirring at 15 rpm will occur for augmentation of heat transfer from the internal heating coils. Experience with a 1 m 3 digester, heated with water from an electric heater, has shown that stable input temperatures were essential for reliable measurements of heat transfer coefficients.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0066
PRODUCTION BY FERMENTATION OF LIPIDS FOR ENERGY
Glatz BA, Hammond EG, Dept. of Food Technology, Iowa State University, *Ames, Iowa, 50010,* (IOW02436)
OBJECTIVE: To explore the value of producing lipid through microbial fermentation of carbohydrate-rich wastes and of using this lipid as a liquid fuel.
APPROACH: Optimize net energy production of fermentations that produce triglyceride oils and other lipids using simple sugars as substrates. Induce mutations in the organisms presently available for lipid production to produce oils with superior qualities as energy sources, to increase the yield of usable oil and rate of oil production in the fermentation, and to allow for lipid production under fermentation conditions that favor net energy output. Examine food processing, agricultural, industrial, and municipal wastes rich in complex carbohydrates such as starch, cellulose, hemicellulose, and lignin as possible substrates for fermentations that produce lipids.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0067
RECYCLING, HEAT EXCHANGE, AND COMMINUTION AS MEANS OF IMPROVING THE ENERGY YIELD FROM AN ON-FARM ANAEROBIC DIGESTER FOR BEEF MANURE
Smith RJ, Iowa Agricultural & Home Economics Experiment Station, Iowa State University, *Ames, Iowa, 50010*
OBJECTIVE: The objective of this proposal is to improve the gas yields and thermal budget of an on-farm anaerobic digester for use on beef manure.
APPROACH: Research has shown that two major problems impeding anaerobic digestion of animal manure are limited digestibility (typically, 40% or less) and fluid-handling difficulties. We propose two strategies for increasing the conversion to methane, one of which will also simplify fluid handling: (1) material will be recycled from the effluent storage tank to the digester for further microbial conversion; and (2) the manure slurry leaving the beef barn will be ground before digestion. The reduction in particle size should enhance microbial activity. The thermal budget of any anaerobic digester would be improved if heat from the effluent, 35 degrees C (95 degrees F), could be transferred to the influent. We propose to construct a mechanically agitated heat exchanger that will simultaneously improve heat transfer and prevent solids deposition. The research will be performed on an existing digester, designed for 60 beef animals, and will also use laboratory digesters.
PROGRESS: The 60-beef animal digester is approximately 90% completed with other funds. The heat exchanger was designed and built to be added to the digester. It was tested with water, and data collected, to optimize the operation and to detemine overall efficiency. The heat exchanger was moved to the digester site and installed on line for testing with the digester influent. The grinder is presently being built.
SUPPORTED BY: U.S. Dept. of Energy.

4.0068
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
Lipper RI, Koch MF, Manges HL, Dept. of Agricultural Engineering, Kansas State University, *Manhattan, Kansas, 66502,* (KAN00778)
OBJECTIVE: Develop optimal manure management systems for animals in confinement housing. Investigate systems of manure management for production of methane and conservation of plant nutrients.
APPROACH: Develop design criteria, make field trials, and evaluate performance of flushing gutter manure transport systems and components for livestock confinement facilities with emphasis on swine. Continue investigation of methane production from anaerobic digestion of swine manure with special reference to the role played by ammonia in the bacterial decomposition of undiluted wastes to methods of scrubbing ammonia and CO(2) from digester gases and capturing ammonia for later use as fertilizer. Measure pollution potential of stormwater and irrigation runoff from corn fields where feedlot manure has been incorporated into the soil at rates ranging from 0 to 300 dry tons per acre per year and develop a suitable field sampler for stormwater runoff.
PROGRESS: Automatic or semi-automatic systems for disposal of animal waste slurries onto land make it possible to dispose of wastes at frequent intervals. Systems that dispose of waste at frequent intervals with low labor requirement could reduce the size and cost of slurry storages, the amount of wastes that produce objectionable odors, and loss of nitrogen fertilizer during storage. Commercially available units using big gun sprinklers have been adapted to such systems. Because of the more or less fixed minimum diameter of nozzle and minimum nozzle pressure for effective handling of solids, disposal rate and cost are too high to be practical for most producers. Extensive field tests had been made in 1978 in which both water and thick manure slurry were pumped onto open disk spinners in much the same way that dry fertilizer is spread. Three different disk angles and numerous vane configurations on the discs were tested. During 1979, additional tests were made in an effort to decrease the fanning effect of air which breaks up water droplets leaving the spinner and reduces greatly the potential trajectory of travel as compared to a stream leaving a nozzle. We conclude that uniform coverage of diameters greater than 50 to 55 feet will be difficult to achieve.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0069
ANAEROBIC DEGRADATION (METHANE FERMENTATION) OF BENZENE RINGS IN PLANT MATERIAL (BENZOIC ACID)
Fina LR, Bridges RL, Dept. of Biology, Kansas State University, *Manhattan, Kansas, 66502,* (KAN00641)
OBJECTIVE: Gain possible insight as to how plant material containing aromatic rings (such as lignin) is degraded anaerobically. Determine the pathway of anaerobic rupture of benzoic acid during methane fermentation.
APPROACH: Use highly enriched mixed cultures and pure cultures of methane producing organisms isolated from the mixed cultures. Sources of cultures are sewage disposal plants (anaerobic digestor), rumen of cattle, or bottom muds of ponds or swamps. Cultures from each source are enriched in all glass fermentors. Study the mixed culture phenomenon intact and the contributions of pure isolated cultures. Isolate pure and axenic bacteria to be used for enzyme preparation. Cell free enzyme preparations to be used study one step reactions.
PROGRESS: Mass culturing for study of enzymes in the metabolic pathway of the anerobic consortium is under study. Techniques in electrophoresis have been developed to purify the proteins (enzymes) involved. A system involving sephadex, gas-liquid chromatography (coincidence peaks) has been perfected for isolation, identification and determination of specific activity of intermediates. From the consortium, we have isolated organisms in pur culture to study the symbiotic relationship. A study of the relationship of the atmosphere over the consortium indicates extreme anaerobic requirement of the consortium. Nitrogen is unsuitable and Helium is the inert gas of choice.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0070
OPTIMIZATION TECHNIQUES FOR AGRICULTURAL PROBLEMS
Fan LT, Hall RC, Dept. of Chemical Engineering, Kansas State University, *Manhattan, Kansas, 66502,* (KAN00737)
OBJECTIVE: Demonstrate applicability of methods of system analysis and synthesis to a variety of agricultural problems including fertilizer production and application, food production and consumption, biomass energy resources conversion and utilization, and water utilization and conservation. The ultimate goal of analysis and synthesis of any system is to optimize its performance.
APPROACH: Multiobjective optimization techniques will be used to simultaneously minimize or maximize two or more objective functions such as production cost and energy efficiency. Experimental optimization techniques will also be used in the optimal design of equipment and apparatus for implementing the predicted optimal policies.
PROGRESS: To maximize the capacity of a cellulose hydrolysis plant, the rate of degradation of cellulose must be enhanced. The rate of degradation of cellulose during enzymatic hydrolysis is affected significantly by the structural features of cellulosic materials. To increase the susceptibility of cellulosic material, structural modification by means of various pretreatment schemes is essential. The effectiveness and mechanisms of three physical and three chemical pretreatment methods were evaluated. This was accomplished by studying the effects of different pretreatments on the hydrolysis rate and on the cellulose structural features which are represented by the two important cellulose structural parameters, crystallinity index and specific surface area. In addition, the relationship among these two structural parameters and the rate of hydrolysis was examined. An empirical expression interrelating them was derived. It appears that both structural parameters influence appreciably the rate of the hydrolysis reaction synergistically. The dynamic characteristics of the membrane-moderated controlled release in which a sinusoidal pertubation is imposed on the surrounding temperature were modeled. A model takes into consideration the nonlinear decay of the active agent and the variant effective mass transfer properties and thermal properties.
SUPPORTED BY: Kansas State Government.

4.0071
MEASUREMENT AND CONTROL OF DUST EMISSION IN GRAIN HANDLING FACILITIES
Martin CR, Lai FS, U.S. Grain Marketing Research Lab., U.S. Dept. of Agriculture, *Manhattan, Kansas, 66502,* (3420-20590-007)
OBJECTIVE: Determine cause and extent of dust emission from grain handling factlities and study methods and equipment for their measurement and control.
APPROACH: Measure dust emission from typical grain handling operations including unloading, loading, weighing, turning, scalping and cleaning. Determine the size range and otherwise characterize particulate emission from handling grain. Determine the effectiveness of conventional cyclone dust control systems and study the use of cloth filters and other methods of collecting dust of microscopic sizes. Develop and test self-contained dust control units to serve individual and/or adjacent dust generating points. Evaluate instrumentation available for monitoring dust emission and develop new or improve existing methods and equipment, including a grain sample dustiness measure.
PROGRESS: We successfully used a light-emitting diode (LED) paired with a phototransistor (PT) to make time-resolved measurements of relative concentrations of dust dispersed in the Hartmann apparatus. The LED-PT probe is inexpensive and is based on simple electronics. Probe response was calibrated in terms of light attenuation by neutral density filters inserted into the light beam. We improved AACC approved method 50-10 for measuring particle size distribution. The operating time for each analysis was reduced by half. The amount of floury material, frass, and damaged kernels caused by developing and feeding insects depended on the rate of development of feeding insects. The rate of development depended on temperature, humidity, grain type, grain density, and species of

insects. We determined the equilibrium moisture content of wheat, corn, sorghum, and soybean dust produced during handling of those grains in marketing channels. The equilibrium moisture content of dust affects their physical and chemical properties that determine the explosibility of dust. A furnace with a fuel capacity of 13.6 kg/h (30 lb/h) of grain dust was designed, constructed, and tested. The efficiency of the furnance ranged from 15 to 30% for heat generated at 7.3 to 13.2 kW (25,000to 45,000 Btu/h). Dielectric properties of corn, wheat, soybean and sorghum grain dusts and corn starch were determined at 1 mHz at 20 degrees C.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0072
ENGINEERING SYSTEMS FOR MANAGEMENT AND USE OF ENERGY FROM BIOMASS
Cochran BJ, Baldwin JD, Dept. of Agricultural Engineering, Louisiana State University, *Baton Rouge, Louisiana, 70803,* (LAB01952)
OBJECTIVE: Determine the feasibility of designing and constructing an on-farm fuel generator using biomass material as an energy source. Determine alternate means of utilizing agricultural products as sources of energy. Characterize and improve energy management strategies for environmentally and economically acceptable crop production systems.
APPROACH: Investigate the various processes known for producing fuels from biomass materials. The processes determined most feasible for farm size generators will be thoroughly evaluated using biomass materials to produce fuels. The types of materials such as crops, weeds, grasses and animal waste, capable of being converted into fuels will be determined. Fuels produced from biomass will be tested for use in internal combustion engines heating buildings and crop drying. Methods of storing fuels on the farm will be considered. Evaluate methods through systems analysis for reducing energy input to crop production. Each cropping operation will be evaluated with respect to all operations to determine the total energy effect of the operation. Techniques of utilizing some agricultural residues as energy for processing with respect to quality, management, and cost will be studied. The feasibility of transporting some residue from the production area will be determined.
PROGRESS: Preliminary studies were made to evaluate the effectiveness of ethanol and vegetable oils as fuel extenders for compression ignition engines. One hundred and ninety proof ethanol was mixed with diesel fuel at 10, 15, and 20% levels. The ethanol would separate from the diesel fuel if constant agitation of the mixture was not maintained. The fuel consumption rate increased slightly as the load increased. Thermal efficiency calculations showed a trend of increasing efficiency as the percentage of ethanol increased up to 20%. This trend needs more detailed study. An open chamber diesel engine was used to evaluate vegetable oil as a fuel. The fuels tested included 100% diesel, 91% diesel + 9% ethanol, 100% peanut oil, 100% corn oil and 50% diesel + 50% soybean oil. There was a significant difference in density among the fuels. It was observed that the vegetable oils were more viscous which affected the pumping and rate of injection into the combustion chamber. Results were promising and a more detailed and sophisticated study will follow.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0073
DEVELOPING NEW PRODUCTS AND IMPROVING PROCESSING METHODS FOR BY-PRODUCTS OF SWEET AND IRISH POTATOES
Constantin RJ, Newsom DW, Hammett HL, Dept. of Horticulture, Louisiana State University, *Baton Rouge, Louisiana, 70803,* (LAB00909)
OBJECTIVE: Develop new products or uses from sweet or Irish potatoes utilizing potatoes that are unmarketable in fresh state. Evaluate varieties and seedlings, methods of preparation, methods of handling and packaging to determine changes occurring in the product to insure good preservation and acceptability.
APPROACH: Emphasis will be placed on production of new products, such as sweet potato chips, frozen French fries, sweet potato sticks, candied yams, yams and fruit, etc. Convenient, ready-to-use products for institutional sales will be investigated. New varieties and selections will be tested for their adaptability.
PROGRESS: Unsuccessful formulas were tried in efforts to produce a desirable, preformed chip or snack product from sweet potatoes. Promotional efforts were continued on 'regular-style' sweet potato chips. A study of the fiber content of sweet potatoes and methods of evaluation was initiated during 1979. Sweet potatoes were found to be higher in dietary fiber (3.7-4.8%) as compared to 2-3% A.O.A.C. or crude fiber normally reported. Some fiber determinations are not suited to sweet potatoes due to high starch content. Cultivars of sweet potatoes from the breeding program and also from the National Sweet Potato Collaborators Regional and observational trials were evaluated for quality--fresh, canned and baked--along with some nutritional evaluations such as fiber, protein and carotene contents. (The regional trial was also packed under 'vacuum' and also in regular syrup pack.) Several new seedlings show promise both for baking and canning. Work was initiated on production of sweet potatoes for alcohol production to use in gas-alcohol mixtures. Several cultivars were used to determine the amount of dry matter (starch) that could be produced per unit area. Cultivars varied considerably in dry matter content. Average dry matter produced per hectare varied from 6,700-11,200kg/ha (6,000-10,000lbs./A) which makes the sweet potato a good source of matter for alcohol production. Quality work on Irish potato cultivars was not performed during 1979 due to crop failure.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0074
PROPOSAL TO CONDUCT A FEASIBILITY STUDY OF THE CONVERSION OF ANIMAL FEEDLOT WASTES TO USEFUL ENERGY
Culley DD, Frye JB, School of Forestry & Wildlife Management, Louisiana State University, *Baton Rouge, Louisians, 70803,* (LA.B02022)
OBJECTIVE: To determine if a dairy farm operation can design its waste management to include a fermentation system for energy production and lagoon system for the production of edible, high protein aquatic plants and be economically feasible or competitive with current dairy farm waste management practices.
APPROACH: Dairy manure will be fermented to generate methane for use as supplemental energy. Various sludge from the fermenter will be used as a nutrient source for aquatic plants. The plants will be cycled back into the animals feed as a protein supplement and the effluent from the lagoon will be used as washwater for the feedlot. Techniques of plant harvest, transportation, and processing will be developed. An economic analysis of the total system will be undertaken to determine capital requirements, return on investment analysis, and cost and energy comparison between current dairy farm practices and a system in which wastes are managed for energy and aquatic plant production.
PROGRESS: Objectives: To obtain an estimate of methane production from dairy wastes, to determine energy and cost comparisons for standard dairy feed production, harvesting, and processing, and waste management with that of high protein aquatic plant feeds produced on lagoons; determine bacterial and viral problems from using lagoon-grown aquatic plants as cattle feed; determine the total cost and energy comparisons between current dairy farm practices and a dairy system managed for energy and aquatic plant production. Accomplishments: Daily harvest of duckweeds yielded 23,310kg/ha/yr of dry material with 37% crude protein. Three-point-one ha of lagoons will yield sufficient protein to meet the annual protein requirements of 100 lactating cows. Methane generated from the manure of 100 lactating cows will provide total energy requirements to operate the dairy farm, excluding vehicle fuel, but may not be economical to meet peak requirements if pressurized. Use of lagoon systems vs conventional scrape and spread handling of wastes (including land crop production and harvest, but not aquatic plant production and harvest) cost about the same. Evidence indicates it will be more economical to use lagoon systems if methane is generated and aquatic crops are harvested.
SUPPORTED BY: Louisiana State Government.

4.0075
GAMMA MODIFICATION OF CELLULOSE FOR USE AS SUBSTRATES IN ENERGY PRODUCTION
Han YW, Timpa JD, Lilleho/ EB, Southern Regional Research Center, U.S. Dept. of Agriculture, Agricultural Research, *New Orleans, Louisiana, 70179,* (7102-20540-003)
OBJECTIVE: Treat lignocellulosics with gamma radiation to minimize the energy required to convert this material into fermentable substrates and substances suitable for chemical feedstocks.
APPROACH: Treat bagasse and other lignocellulosics with varying levels of gamma to determine the optimum level required for maximum separation of cellulose from lignin. Chemically characterize gamma-modified macromolecules. Use presensitization treatments of bagasse to determine synergistic effects on cellulose release. Vary combinations of chemical and irradiation treatments to achieve desired end products.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0076
TIME-TEMPERATURE RELATIONS OF ENZYMATIC CONVERSION OF POLYSACCHARIDES TO SUGARS IN SWEET POTATO ROOT
Bouwkamp JC, Solomos T, Dept. of Horticulture, University of Maryland, *College Park, Maryland, 20740,* (MD-L-080-A)
OBJECTIVE: Determine the feasibility and yield of ethanol from sweet potatoes. Verify the dry matter yield potential of sweet potatoes grown for the full season. Determine optimum pre-fermentation conditiins utilizing native and added enzymes resulting in a maximum production of ethanol.
APPROACH: Replicated yield trials will be conducted for 2 years and dry matter yield calculated. Time-temperature studies on the activity of native beta-amylase will be conducted. At the conclusion of the time-temperature study, samples will be fermented with and without added cellulase and pectinase and ethanol recovery will be determined.
PROGRESS: Yield trial results were 20 mt/ha total yield of roots containing 31% dry matter. Prefermentation treatments at tempertures below 60 degrees C were not effective in activating the native amylases. Treatments at 70 degrees or 80 degrees gave similar results, with 80 degrees resulting in slightly higher conversion as measured by refractive index. Fermentation time was not greatly different among the various treatments.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0077
PRACTICAL STUDIES WITH BROILERS AND LAYING HENS
Johnson EL, Dept. of Poultry Science, University of Maryland, *College Park, Maryland, 20742,* (MD-M-075)
OBJECTIVE: To determine the effectiveness of adding dietary supplements, such as copper, and ingredients not frequently used, such as rye, and by-products from fermentation products (e.g., gasohol production) on broilers and laying hens. To determine the effect of management practices, such as type of litter, density, and variations in light regimes, on bird production.
APPROACH: Floor pen studies with broilers will be conducted to determine the effect of adding copper to broiler feeds. The copper build-up in the litter will be measured, and the effect of this copper on the microbial population will also be studied. Experiments will be conducted to re-evaluate the protein and energy levels for practical broiler diets. Studies will be conducted with broilers and hens to determine the value of ingredients that may become available in the future that are not currently used in large amounts.
SUPPORTED BY: Maryland State Government.

4.0078
ANAEROBIC DIGESTION PROGRAM SUPPORT
Jantzen D, Dynatech Research & Development Co., *Cambridge, Massachusetts, 02139,* (NR 9 8175 01)

OBJECTIVE: The first objective involves: (1) performing computer-aided engineering analysis and system studies of selected anaerobic digestion processes; (2) attending anaerobic digestion contractor review meetings and keeping up with contractors' research results; and (3) making site visits, performing engineering calculations, and assisting in technical proposal reviews, program planning and status report development and presentation. The second objective involves performing a technical and economic feasibility analysis of a corn-stover-to-methane conversion system including: (1) a comparison of the Gaddy and Pfeffer conversion processes with processes to be developed in terms of process-plant size, pretreatment and digestion processes, kinetic rates, percent conversion, capital and operating costs, produced gas costs, etc.; and (2) an interpretation of the feasibility of building and operating the Gaddy system with the estimated costs. The third objective is to: (1) develop information about the types, concentrations, biodegradability, and locations of secondary agricultural residues such as cheese whey, pulp liquors, and vegetable processing wastes; (2) evaluate and present this data; (3) perform engineering analysis to determine the feasibility of converting these residues to alcohol or methane and study the economics involved; and (4) assess institutional problems involved in conversion, sales, and distribution. The fourth objective is to revise work on the basis of updated reports of new yield and kinetic data and to provide new cost projections for crop-residue-to-methane conversion based on the latest experimental results analyzed for three sizes of systems (small, cooperative, and industrial), three types of systems (batch, plug flow, and CSTR), and three crop residues (corn stover, wheat straw, and rice straw).
SUPPORTED BY: U.S. Dept. of Energy.

4.0079
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
Gerrish JB, Dept. of Agricultural Engineering, Michigan State University, *East Lansing, Michigan, 48823,* (MICL01066)
OBJECTIVE: Develop optimal animal manure management systems. Characterize atmospheric contaminants and develop abatement methods to eliminate the contaminants' potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant-nutrients, and other potential uses. Characterize the non-point pollution water runoff sources from livestock and poultry enterprises on pasture production systems and land areas with manure application and to further develop guidelines for abatement of non-point pollution sources from animal manures.
APPROACH: Study hydraulic transport of manure as practiced in flushing systems. This will lead to design recommendations and workable plans. Modelling studies are already well underway. In odor control, we are studying the effects of ozone on swine waste. Also studying the culture of purple sulfur bacteria as an odor modifier in anaerobic lagoons. Hope to develop procedures to foster such a culture under Michigan climatic conditions. Studying liquid-solid separation for its potential as a step in a fermentation process leading to a re-fed product. Have two year's data from some spring-thaw runoff events at a system of 12 plots where manure was applied on the frozen ground. This study will continue in an attempt to develop control strategies which would minimize non-point source pollution. (20% basic research; 60% applied research; 20% development effort).
PROGRESS: Work with anaeobic swine waste lagoons containing purple sulfur bacteria for odor control has centered around management techniques to promote early growth of the bacteria during spring warm-up. Maintaining a light load on one of two lagoons during winter months has helped promote early growth of bacteria in the lightly loaded lagoon. Experimentation with agitation, pump downs and dilution of the more heavily loaded lagoon with effluent from the lightly loaded one followed by interchanging the loading rates on the two lagoons has helped "start up" the more heavily loaded lagoon in spring. A field project to determine nutrient losses in dairy manure storages was started. Seven dairy farms with different types of manure storage systems were identified and manure sampled as it went into and was later taken out of storage for land application.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0080
UPGRADING LOW QUALITY FORAGES FOR LACTATING COWS THROUGH TREATMENT WITH VARYING LEVELS OF AMMONIA
Huber JT, Dept. of Dairy Science, Michigan State University, *East Lansing, Michigan, 48823,* (MICL03079)
OBJECTIVE: Determine the effect of ammonia added to corn stalk silage on fiber breakdown, silage fermentation, and protein synthesis during ensiling. Determine the extent of conversion of ammonia into milk protein when added to corn stalk silage. Determine the effect on fiber breakdown of adding combinations of NH(3) to corn stalk silage.
APPROACH: Fermentation in laboratory silos will be investigated using 0-7% ammonia to study nitrogen fractions and fiber breakdown. Digestibility studies will be conducted in cattle to determine the effect of ammonia treatments on cellulose utilization. Studies with lactating dairy cows will ascertain the feeding value of the ammonia-treated materials as replacements for conventional forages.
PROGRESS: Research is underway comparing the nutritional value for lactating cows of corn stalks ensiled immediately after high moisture corn harvest with that of corn silage. Other treatments include addition of varying amounts of ammonia to the ensiled stalks (stalkage). Currently, a lactation trial is in progress and a digestibility study is planned for the near future. Upgrading corn crop residue utilization is becoming more important with the diversion of a large proportion of the corn production to gasohol. The ammonia is added to furnish nitrogen, improve preservation, and, at higher levels, increase the energy utilization of the ensiled stalkage.
SUPPORTED BY: Michigan State Government.

4.0081
ANIMAL WASTE MANAGEMENT SYSTEM FOR THE 1980'S
Thomas JW, Dept. of Dairy Science, Michigan State University, *East Lansing, Michigan, 48823,* (MICL01078)
OBJECTIVE: Conceptualize, develop, analyze, and optimize animal manure management systems with least cost and energy requirements for pollution control compatible with changing sociopolitico-economic patterns. Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein. Characterize atmospheric contaminants and to develop abatement methods to eliminate the contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses with consideration of the human, animal and plant health factors.
APPROACH: Manure simulating that in liquid manure pits but held in laboratory jars will be treated with chemicals and odor evaluated by several persons. Nitrogen loss will be measured. Excreta of different types (varying animal source and fresh or dried, etc.) and dry matter contents will be added to corn forage and the mixture ensiled. Silage characteristics and animal acceptability and performance will be measured.
PROGRESS: No experiments have been performed on direct feeding of wastes to animals during the year. Kidney and liver analysis from lambs fed 16-32% dried caged layer excreta showed normal concentrations of major and trace minerals. A fermented waste product is being fed to cows. Feeding animal wastes to cattle in Michigan has not occurred as a usual farm practice. Economic considerations may change this situation.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0082
AN ECONOMIC ANALYSIS OF MINNESOTA FARM ADJUSTMENTS TO INCREASING ENERGY PRICES
Eidman VR, Dept. of Agricultural & Applied Economics, University of Minnesota, *St. Paul, Minnesota, 55101,* (MIN-14-094)
OBJECTIVE: Estimate the energy embodied in capital inputs. Estimate optimum adjustments in resource use, production methods, and output on representative Minnesota farms as energy prices increase. Estimate aggregate shifts in energy use and production by Minnesota's commercial agriculture as energy prices increase.
APPROACH: Firms producing livestock equipment, farm buildings, and irrigation equipment will be asked to monitor all energy inputs and the amount of output produced. Mathematical programming and simulation models will be used to determine the optimum adjustment as energy prices increase. Estimates of aggregate adjustments will be prepared by solving the representative firm models and a price adjustment model in an iterative manner.
PROGRESS: An analysis of using blended alcohol and diesel fuel in farm tractors was based on tractor performance data provided by the Dept. of Agricultural Engineering and a study estimating the cost of producing ethyl alcohol from corn listed in last year's report. The results indicate that blending ethanol with diesel fuel and using it as fuel for a farm tractor is less economic than blending ethyl alcohol with gasoline for use in a spark ignition engine. A technical bulletin describing a method to use in estimating real grain storage costs during periods of inflation and rising real energy costs was published. The bulletin also lists the components for eight alternative drying and storage systems and provides detailed estimates of investment, operating and ownership costs. This information is of interest to those building grain storage systems. A paper contrasting methodologies that can be used to analyze the impact of increasing real energy prices on the interregional competitive position of an area in the production, processing and distribution of food was prepared. This paper provides a starting point to analyze the impact of changing energy prices on the competitive position of Minnesota in crop and livestock production.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0083
FARM ANIMAL WASTE MANAGEMENT
Goodrich PR, Moore JA, Dept. of Agricultural Engineering, University of Minnesota, *St. Paul, Minnesota, 55101,* (MIN-12-060)
OBJECTIVE: Evaluate gases from manure for chemical components and effects on man and animals. Evaluate methods of reclaiming, storing, processing, and refeeding animal wastes back to animals for effect on animal health and production. Develop components for collection, storing, treating of animal manure and evaluate their economy, effect on production, and their effect on environment. Evaluate effect of rates, frequency of applying animal manure to soils.
APPROACH: Manure gases have been analyzed by gas chromotograph and evaluated using human odor panels. Limited results are available relating gas composition, production to various waste management systems; effects on animal, human health, and production. Reclaiming, recycling the usable constituents has been studied to determine palatability and feed conversion on a limited number of animals. Detailed investigations of toxicity, microbiological effects, and residual storage of pharmaceuticals in the animal are lacking. Evaluations of separating, storing, and handling systems are extremely limited and not available for waste management in cold climate.
PROGRESS: The digester situated on a swine farm has continued to work successfully. The materials handling problems have been solved by using a chopper pump of sufficient capacity to cut up the waste. The pump agitates and fills the tank well. The low-cost injector fed by a pump through a tow line hose was successfully used by several farmers to inject hog waste. This low-odor method of waste injection saves an additional 20-25% nitrogen. Laboratory studies of an anaerobic filter for treating liquid swine wastes shows good potential. The floc-media filter works best in removing

soluble nutrients and works at rather short detention times compared with the anaerobic digester. The gas is about 70-80% methane and can be used as fuel.
SUPPORTED BY: Minnesota State Government.

4.0084
REDUCTION OF NON-RENEWABLE ENERGY CONSUMPTION FOR GRAIN DRYING
Morey RV, Cloud HA, Gustafson RJ, Dept. of Agricultural Engineering, University of Minnesota, *St. Paul, Minnesota, 55101,* (MIN-12-023)
OBJECTIVE: Evaluate energy utilization of combination high-temperature, low-temperature drying systems for shelled corn. Develop recommendations for design and management of low-temperature, ambient-air drying systems for corn and other grains under Minnesota weather conditions. Evaluate the potential for using crop residues to supply heat energy for high-temperature, high-speed grain drying.
APPROACH: Combination high-temperature, low-temperature drying will be evaluated under field scale conditions. Propane and electrical energy requirements will be monitored. Computer simulation will be used in evaluating the performance of low-temperature, ambient-air drying systems. Design and management recommendations will be based on these results. Evaluation of the potential for using crop residues will include feasibility analysis, evaluation of existing devices for energy recovery from residues and demonstration scale research on crop residue fired drying system.
PROGRESS: Summary of 4 years (1975-78) of experiments involving combination high-temperature, low-temperature drying and conventional high-temperature drying of corn was completed. Results showed conventional drying from 25.5 to 15.5% w.b. required 778 MJ/t of propone energy and 13 MJ/t of electrical energy. Combination drying using high-temperature to dry from 25.5 to 21.5% followed by low-temperature from 21.5 to 15.5% required 254 MJ/t of propane energy and 118 MJ/t of electric energy. Combination drying resulted in reduced susceptibility to breakage and substantially increased drying capacity compared to conventional drying. Analysis of low-temperature drying performance at 3 locations (St. Cloud, MN; Des Moines, IA; Indianapolis, IN) using computer simulation showed little increase in drying reliability and a modest reduction in fan energy requirements if supplemental heat were used compared to ambient air drying. Ambient air drying experiment with wheat was carried out in Summer 1979. Data were used to validate a computer model of ambient air wheat drying. Results showed operating fan by humidistat control after drying front reached top of bin resulted in reduction in energy use with deterioration levels comparable to continuous fan operation. Dry-matter-decomposition levels increased rapidly above 19% moisture control.
SUPPORTED BY: Minnesota State Government.

4.0085
COMBUSTION OF CROP RESIDUES TO DRY CORN
Morey RV, Hartsock JG, Dept. of Agricultural Engineering, University of Minnesota, *St. Paul, Minnesota, 55101,* (3090-20591-030-C)
OBJECTIVE: Characterize crop residues as fuel sources for drying corn and develop design criteria for combustors of downdraft or crossdraft design. Evaluate methods for mixing combustion gases with ambient air so that the mixture will not damage nor contaminate grain exposed gases with ambient air so that the mixture will not damage nor contaminate grain exposed to it.
APPROACH: Collect corn residue samples including cobs, stalks, and leaves. Determine their heat values by bomb calorimetry and ash content by ASTM procedures. Determine storage characteristics for various moisture contents, temperatures and storage periods. Develop a laboratory scale combustor to evaluate downdraft and crossdraft combustion having output about 100,000-200,000Btu/hr. Vary grate configuration, air introduction methods and residue feeding mechanisms and evaluate heat release/unit grate area, conbustion efficiency, and exhaust gas temperature and composition. Evaluate methods and devices for mixing combustor exhaust with ambient air to provide desired drying temperature. Analyze mixture composition & evaluate corn samples exposed to the mixture for undesirable odors or discoloration as indicators and problems requiring further analysis.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0086
ALCOHOL PLANT DEMONSTRATION AND DEVELOPMENT
Jones RD, No Performing Institution Reported, *Minnesota.*
OBJECTIVE: The work will consist of building a farm size alcohol plant and making modifications needed to use potatoes as a feed stock. One of the objectives will be to assemble information such as parts needed, where to obtain them, approximate costs and other information to be available to others interested in building farm size alcohol plants. The separation of solids from the beer is one problem to be worked out when using potatoes. The main objectives are to build a working alcohol plant that people can afford to build and provide them with the information to do it.
SUPPORTED BY: U.S. Dept. of Energy.

4.0087
ENERGY MANAGEMENT IN A BIO-GAS-ETHANOL PRODUCTION UNIT
Harris FD, Dept. of Agricultural Engineering, University of Missouri, *Columbia, Missouri, 65201,* (MO-00076-1)
OBJECTIVE: Improve the present negative energy balance in the production of ethanol by utilizing the waste energy from an internal combustion engine. Develop a control methodology to simplify the operation of a bio-gas-ethanol energy system.
APPROACH: A spark ignition engine will be fueled by bio-gas from a swine manure digester. An AC generator coupled to the engine will provide electrical energy for various loads. Engine cooling water will maintain a digester temperature of 94 degrees F. Energy in the exhaust gas from the engine will be used in the distillation process. Control values will maintain the system at an optimum condition for each mode of operation.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0088
MICROBIOLOGY OF MESOPHILIC, ANAEROBIC DIGESTION OF ORGANIC MATTER
Iannotti EL, Fischer JR, Sievers DM, Dept of Agricultural Engineering, University of Missouri, *Columbia, Missouri, 65201,* (MO-00087)
OBJECTIVE: Characterize the anaerobic process and the microbial population by which swine manure and plant matter is converted to methane, alcohols, short chain acids, and microbial cells at mesophilic temperatures.
APPROACH: The activity of the total population will be defined by determining the types and quantities of microorganisms present and by determining the chemical and physical parameters and the flow of carbon during the anaerobic degradation of swine manure and plant matter. The major bacteria in the process will be isolated and characterized in terms of general properties, metabolism, and nutritional and chemical-physical requirements.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0089
LIVESTOCK RESIDUE UTILIZATION SYSTEMS
Sievers DM, Fischer JR, Iannotti EL, Dept. of Agricultural Engineering, University of Missouri, *Columbia, Missouri, 65201,* (MO-00080)
OBJECTIVE: Develop livestock residue management systems which are adaptable to Missouri's conditions and maximize resource utilization.
APPROACH: Livestock residue utilization systems holding the most promise for adoption under Missouri conditions will be incorporated into existing and future animal production facilities on university farms to study their value for pollution abatement and resource utilization. Systems will be installed and studied as components such as collection, treatment, processing and utilization components. Components to be studied include hydraulic flushing, solids-liquid separation, settling basins, anaerobic lagoons, soil-plant filters, anaerobic digesters, oxidation ditches, and irrigation equipment. Cooperative research with private producers will be used where appropriate opportunities exist to evaluate unique components or systems and where field installations can serve as demonstrations to the farming community.
PROGRESS: Studies on buffer relationships in swine digesters indicate that NH(3) and HCO -(3) buffers combine to maintain chemical stability by maintaining pH in a desirable range. Stability is a function of carbon and nitrogen loading which can be expressed as the C/N ratio. Stable digestion occurred within a range of C/N ratio of II/1 to 15/1 and with HCO(3) above 6000 mg/L (CaCO(3)). High HCO(3) levels appear to permit digestion at high nitrogen concentrations as stable gas production was achieved at 663 mg/L free NH(3). Results indicate that organic loading of swine digesters can be increased over current levels if C/N ratio and HCO(3) are maintained at proper levels. Successful digestion has been obtained at a loading of 7.2 g VS/L.d. This is being further tested by combining swine manure with chemically treated straw. Gas agitation of swine digesters did not increase gas production significantly and energy inputs for mixing can be minimized. Benefits of agitation appear to be dispersion of scum and increased heat transfer.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0090
EQUIPMENT AND STRUCTURES FOR ON-FARM ENERGY PRODUCTION AND UTILIZATION FROM AGRICULTURAL WASTES AND RESIDUES
Fischer JR, U.S. Dept. of Agriculture, Agricultural Research, University of Missouri, *Columbia, Missouri, 65201,* (3402-20400-006)
OBJECTIVE: Determine physical, biological, and chemical relationships that occur during anaerobic digestion of agricultural residues. Develop equipment, operating technology, and management procedures for on-farm production of methane gas from agricultural residue. Develop a method whereby methane gas may be effectively utilized on the farm to replace the use of fossil fuel energy, and evaluate the recycling of digester effluent as a source of fertilizer.
APPROACH: Laboratory studies will be conducted using six, 20 liter model digester systems to evaluate agitation requirements, effects of antibiotics, and the effect of rations on anaerobic digestion of swine manure for biogas production. A 420 liter prototype digester will be used to study the effect of loading rate on biogas production. Also this unit will be used in a comparison study of mixed mesophillic digestion with plug flow digestion. The farm size digester will continue to be used to: define management problems, verify reliability of equipment and the automatic control system, maximize gas production from recycled solids and conservation of energy, and evaluate energy and effluent utilization.
PROGRESS: Objective was to improve and transfer anaerobic digester technology and to adapt this technology to farm-size operations as an alternative energy and fertilizer source and as a pollution control measure. The farm-size swine manure digester operated satisfactorily. The 15 ft (3) model digester was operated this year to determine the maximum and/or optimum loading rate of swine manure. The digester operated successfully at a loading rate of 0.40 lbs VS/ft (3) but failed at 0.45 lbs VS/ft (3). Varying the duration of gas agitation from no agitation to 9 hr/day using six 20 L digesters did not change the amount of gas produced. Microbes responsible for converting swine manure to methane can be grouped at the genus level and subgroup based on the nutritional information developed. Stimulatory growth factors in the influent are being determined. A modified Warburg apparatus was designed, constructed and is now being operated to determine the effects of antibiotics on swine manure digestion. Data from field experiments on utilizing the effluent indicated that the same yield of corn can be obtained with the nitrogen supplied by commercial fertilizer or by digester effluent.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0091
ECONOMIC EVALUATION OF THE USE OF MONTANA AGRICULTURAL PRODUCTS AND BY-PRODUCTS
McConnen RJ, Dept. of Agricultural Economics, Montana State University, *Bozeman, Montana, 59715,* (MONB00084)
OBJECTIVE: Evaluate economic feasibility of the commercial production of syrups and associated products from high lysine barley. Evaluate the economic impact on both the from agricultural products and by-products. Evaluate the economic impact on both the agricultural sector and the regional economy of promising alternative commercial uses.
APPROACH: Work with other scientists, principally in the technical areas, to develop a profile of input-output relationships with particular emphasis being given to the characteristics of outputs. Conduct a preliminary market evaluation for outputs with particular emphasis gien to possible substitutes. Conduct a preliminary economic feasibility evaluation of promising alternatives. For those alternatives which show economic promise, develop a plan for detailed evaluation and implementation and either seek added funds to complete the work or find other groups who would complete the work.
PROGRESS: Served as a member of Montana Gasohol and Biofuels Advisory Council and prepared background material for the group. Also served as a member of the Montana State University Biofuel Task Force and worked with members of that group to develop proposals and define alternatives. Work done to date will serve as basis for increased activity in rest of this fiscal year.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0092
OPTIMIZING AGRICULTURAL WASTES TREATMENT
Robbins JE, Dept. of Chemistry, Montana State University, *Bozeman, Montana, 59715,* (MONB00257)
OBJECTIVE: Investigate the impact on fermentation of wastes by the addition of carbohydrate from wheat straw and the addition of selective metabolities; review biological delignification studies. Synthesis of lignin models, study soil bacteria that are known to decompose lignin, genetic alteration and screening of soil bacteria. Evaluate the impact of fermentation of high carbohydrate levels on the fertilizer value of liquid effluent from an anaerobic digester.
APPROACH: The parameters which cause a digester to "sour" or fail may be elucidated by monitoring the profile of volatile acids during fermentation of high glucose levels and glucose metabolities. Genetic alteration of soil bacteria involed in lignin degradation was tried with chemical mutagens. Mutants which degrade lignin more efficiently will be screened by monitoring decomposition of lignin model compounds. The fertilizer value will be assessed by quantitative analyses of nitrogen, phosphorus, potassium, calcium, magnesium and iron. The analyses will be performed on effluent from norminal loading and higher loading rates.
PROGRESS: The significant accomplishments from this project include the following items. The demonstration of the impairment to conversion imposed by lignin in wheat straw. This clearly demonstrated the need for research on biological delignification. Only half the available energy can be realized without the removal of lignin. The efficiency of fermentation of cellulose and cattle manure mixtures has been demonstrated to be optimized with 40% cellulose and 60% manure solids. This maximizes solid conversion and fuel production. The fermentation was also shown to be stable. This is important for considering the type of wastes that can be mixed to provide maximum fuel production and no danger of fermenter failure. Studies have been conducted which have elucidated factors involved in destabilizing anaerobic fermentation. These studies have shown the major contribution to fermenter failure arises from metabolic activity of the fermentative and acetogenic classes of anaerobes and not the methanogenic classes as previously believed. These findings are important in considerations for single stage as opposed to two stage fermentations.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0093
ANAEROBIC FERMENTATION OF LIVESTOCK AND CROP RESIDUES
Hashimoto AG, Chen YR, Prior RL, U.S. Meat Animal Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Clay Center, Nebraska, 68933,* (3415-20400-005)
OBJECTIVE: Determine feasibility of anaerobic fermentation to recover methane, protein, and plant nutrients from agricultural residues.
APPROACH: The work plan is divided into four tasks: parametric testing, biomass recovery, biomass nutritive evaluation, and scale-up and economic evaluation. Parametric testing evaluates the effects of operating parameters (mixing, temperature, residence time, and loading rate) on biomass and methane production. Biomass Recovery will be by centrifugation and lower cost solids recovery systems. Biomass nutritive evaluation consists of the chemical composition of the biomass and in vitro and in vivo digestibility. Capital and operating costs of the overall system will be evaluated.
PROGRESS: The effect of temperature on methane production rate and substrate biodegradability has been determined, and a kinetic model has been developed to predict this effect. Methane production rate increased as the fermentation temperature increased up to 60 degrees C, then decreased sharply as the temperature continued to increase. We also found that fermentation temperature did not affect the biodegradability of beef cattle manure. These results were used to develop a kinetic model to predict methane production rates of fermenters operated at different temperatures. Manure from cattle fed high roughage rations produced less methane than from low roughage rations (0.173, 0.232 and 0.290 L CH(4)/g VS fed for rations containing 91.5, 40 and 7% corn silage, respectively). Chlortetracycline and monensin did not affect the ultimate methane yield (0.294 and 0.267 L CH(4)/g VS fed for manure containing chlortetracycline and monensin, respectively, compared to 0.290 L CH(4)/g VS fed for the control). However, monensin delayed the start of methane production in batch fermentations. Studies on feeding the fermenter effluent to sheep and cattle showed varied results. A 158 day growing-finishing experiment showed a 20% decrease in average daily gain of cattle fed effluent compared to controls fed soybean meal. A subsequent experiment showed no difference in average daily gain of cattle fed effluent and the controls.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0094
WASTE MANAGEMENT IN HOUSED AND OUTDOOR BEEF AND SWINE FEEDLOTS
Schulte DD, Gilbertson CB, Dept. of Agricultural Engineering, University of Nebraska, *Lincoln, Nebraska, 68508,* (NEB-11-035)
OBJECTIVE: Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein. Characterize atmospheric contaminants and develop abatement methods to eliminate the contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production, and other potential uses with consideration of the human, animal, and plant health factors. Characterize the non-point pollution water runoff sources from livestock and poultry enterprises on pasture production systems and land areas with manure application and to further develop guidelines for abatement of non-point pollution sources from animal manures.
APPROACH: Field sink installed to collect the solids from the feedlot and effluent is disposed. Direct disposal of effluent applied to a vegetated, low-gradient serpentine water way. Area on high traffic outdoor feedlot stabliized with hydrated lime. New waste management facilities designed to conduct research on removing, handling, treating, storing, utilizing, and disposing of beef and swine manures. Atmospheric contaminants from feedlots and housed-livestock measured. Separation of solids and liquids by mechanical means of beef and swine manure. Oxidation ditch modified to surface type drag manure cleaner. Effluent from settling pond recycled for conversion of energy.
PROGRESS: Solids separator for a 450-sow swine unit was completed and is under study at a cooperator site. The unit has been handling up to 530 m (3) of flushed waste per day. The quality of solids removed averaged 65% by volume (58% by weight) using a 1 x 2 m slotted screen. Average total solids content of the solids removed were 19.5% and 17.5% for the auger and ram pump methods of cleaning, respectively. The "stored" separated solids averaged 23% total solids. Preliminary work has been completed on "predictability of manure constituents as affected by rations". Results of this study are available in thesis form. Laboratory work was completed to determine the fate of nitrogen in manure storage units. Data is being analyzed for publications in the 1980 Proceedings of International Symposium of Livestock Wastes.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0095
PRECIPITATION OF ETHANOL STILLAGE TO IMPROVE PROTEIN AND RECYCLE WATER
Klopfenstein TJ, Britton RA, Dept. of Animal Science, University of Nebraska, *Lincoln, Nebraska, 68508,* (NEB-13-059)
OBJECTIVE: Develop a simple method of precipitating the proteins in distillers solubles. Clarify distillers solubles so that the water could be recycled. Increase the protein value of distillers solubles for ruminants. Determine the precise protein bypass and amino acid availability values of distillers grains, distillers solubles and corn gluten meal for ruminants. Develop a system of incorporating distillers grains, distillers solubles, and corn gluten meal into ruminant rations to optimize their value.
APPROACH: While stillage and thin stillage (distillers solubles) will be treated by various techniques to determine the most effective means of precipitation the proteins, primarily yeast cells. The various proteins produced as products to ethanol production from grain will be evaluated with beef calves. The proteins will include distillers grains, distillers soubles and proteins precipitated from distillers solubles with bentonite or other practical procedures.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0096
ETHANOL FOR FUEL - PRODUCTION BY ZYMOMONAS
Chase T, Eveleigh DE, Montenecourt BS, Dept. of Biochemistry & Microbiology, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJ01503)
OBJECTIVE: Simplify conversion of agricultural biomass (starch) to ethanol, a liquid transportation fuel, by constructing a hybrid bacterium, Zymomonae, able to degrade the starch and ferment it continuously to ethanol at a high temperature.
APPROACH: Thermotolerant Zymomonas strains will be selected. Fermentation conditions with starch-derived glucose syrup as substrate will be optimized. Levels of enzymes of the fermentation pathway will be determined. Zymomonas cells will be immobilized for continuous fermentation. Starch degrading pseudomonads will be hybridized with Zymomonas by conjugation, transformation with isolated DNA, or transformation via plasmid intermediates. Hybrids will be characterized with respect to stability, ethanol yields, and rate of starch degradation.
PROGRESS: Three Zymomonas strains were obtained, TCRP-1 from the American Type Culture Collection (#10988) and CP3 (var. recifensis) and AG11 (Mexican) from Dr. Osvaldo Goncalves de Lima, University of Recife, Brazil. They showed the same growth rate at temperatures 30 to 36 degrees C (on 0.5% yeast extract - 2% glucose); cell yield decreases with increasing temperature. The doubling time is 2.5 hr at 36 degrees C. Cells transferred to tubes at 39 degrees C failed to grow; increasing temperature in one degree steps showed growth

up through 37 degrees C. Overnight incubation at 39 degrees C in ethanol solutions (5% or higher) killed the cells, indicating that ethanol and high temperature may be synergistic in cell death and making high temperature fermentation more difficult. We have also obtained amylolytic strains of Pseudomonas for transfer of the amylase gene to Zymomonas.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0097
ENZYMATIC DEGRADATION OF POLYMERS PRODUCED BY PLANT AND FUNGAL CELLS
Eveleigh D, MacMillan J, Chase T, Dept. of Biochemistry & Microbiology, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJ01111)
OBJECTIVE: Produce catabolite repression resistant hypercellulase mutants of T. viride and clarify the mechanisms controlling the synthesis of cellulase.
APPROACH: This project is directed to the microbial conversion of waste agricultural materials into useful by-products. Waste cellulosics (corn stalks, etc.) can be degraded to glucose enzymatically using microbial enzymes, and this product fermented to ethanol - a useful energy sparing material. Analogously, the waste agricultural components can be up-graded to high quality single cell protein by successive action of microbial enzymes and growth of food yeasts.
PROGRESS: In order to reduce the cost of conversion of biomass to sugars, a range of microbial mutants have been selected that hyperproduce cellulase. This cellulase from the fungus Trichoderma reesei is particularly effective in saccharifying crystalline cellulose. Mutant strains have been selectively isolated that (a) produce excessive amounts of cellulase, (b) will synthesize cellulase in the presence of readily metabolizable sugars (catabolite repression resistant), (c) show some decrease in the level of end-product inhibition, (d) produce thermally stable cellulases. Initial pilot plant fermentations indicate the characteristics of these mutants are maintained in large scale culture. The characteristics of these mutants make them of potential commercial application.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0098
DEVELOPMENT OF A SYSTEM FOR LOW COST METHANE GENERATION FROM CROP AND ANIMAL RESIDUES
Jantzen D, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (XB 0 9038 0101)
OBJECTIVE: To complement previous development of a digestion system for conversion of dairy manures to methane, Cornell has been experimenting with dry digestion systems for converting crop residues to methane. The objectives are: (1) to determine the reaction kinetics of dry crop residue digestion as a function of temperature, feedstock, nutrients, mixing, moisture, etc. and to determine the energy flows in and out of such a system; (2) to determine the technical and economic feasibility of dry digestion of crop residues for farm-scale and larger-scale systems; and (3) to design a proof of concept-scale dry fermenter.
APPROACH: The tasks will include: (1) operating two existing 38 m(3) digesters (plug flow and conventional) for one year to compare relative reactor wear and maintenance problems; (2) experimentally examining the kinetics of dry digestion of crop residues, using several small reactors (feedstocks will include wheat straw, corn stover, and one other substrate); (3) conducting a technical and economic feasibility analysis of dry fermentation systems, based on the results of task 2; and (4) designing the proof of concept-scale dry digester, using the information obtained in tasks 2 and 3.
SUPPORTED BY: U.S. Dept. of Energy.

4.0099
AUTOHEATED AEROBIC THERMOPHILIC DIGESTION WITH AIR AERATION
Jewell WJ, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123331)
OBJECTIVE: Determine the practical feasibility of treating municipal primary and secondary sludges with autoheated theromophilic digestion using air aeration. This will be accomplished with an existing full scale commercially available process identified the "Licom System." Relate the organic loading rates of sludges to autoheating capability, determine effects of autoheated aerobic treatment of sludge on stabilization (rates and quantity) and dewaterability of the sludge, and determine aeration and oxygen transfer requirements for autoheating.
APPROACH: A full scale thermophilic digestion system has been demonstrated to be capable of autoheating cow manure slurries of 95% moisture at 63 degrees C at Cornell University. This system is completely isolated with separate feed storage tanks, two stage completely mixed 1000 ft reactors, automatic continuous feed pumps and large effluent storage tanks. The majority of information will be developed with primary sewage sludge with combinations of primary and secondary sludge tested in the later phases. All full scale testing with primary sludge will be completed in one year. The sludge will be trucked into this facility from a nearby town. Small scale laboratory reactors will be operated simultaneously with the large scale units to obtain detailed information on substrate removal kinetics and impact on other sludge characteristics.
PROGRESS: A full scale study (28.4 m (3) reactor) demonstrated that simple self-aspirating aerators (ambient air) could achieve high oxygen transfer efficiencies and thereby allow conservation of the heat of oxidation to achieve autoheating to high temperatures. Continuous feed operation of a one-stage digestion system utilizing a feed of primary and waste activated sludge (3%-6% total solids) resulted in autoheated reactor temperatures ranging from 45 degrees C to 65 degrees C. The relationship between process variables and the autoheating phenomena were examined at full scale and bench scale levels. The process variables included organic loading rate and dissolved oxygen concentration. It was observed that intermediate loading rates (12-15 kg TS/m (3) reactor-day) and low dissolved oxygen residuals (less than or equal to 1 ppm) allowed maximum temperature development. Two different aerators were tested and were found to achieve oxygen transfer efficiencies exceeding 20%.
SUPPORTED BY: New York State Government.

4.0100
ANAEROBIC FERMENTATION OF AGRICULTURAL WASTES - POTENTIAL FOR IMPROVEMENT AND IMPLEMENTATION
Jewell WJ, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123360)
OBJECTIVE: Determine the potential for optimizing technology related to anaerobic fermentation of agricultural wastes; identify fermentor designs capable of more rapid or more efficient recovery of energy containing by-products of gas, nutrients and solid residues, and to demonstrate the feasibility of improved fermentors using small laboratory models followed by large scale pilot plants. Studies will be conducted with dairy cow wastes.
APPROACH: This study will be divided into 3 major efforts: identification of improved fermentor designs using small scale laboratory models, definition of optimized fermentor designs, and demonstration of new process feasibility in large scale pilot plants. Two general concepts will guide the development of future optimized anaerobic fermentation technology: Simplistic operation involving minimal manpower and the elimination of the waste by production of useful energy-containing by-products. The focus will be on the transformation of a "waste" into useable but currently unrecovered energy-containing by-products. The Cornell study has identified two unique anaerobic fermentation system designs: One could be capable of operation with the simplest of demands on the farm; whereas a complex unit may accomplish stabilization, methane production, liquid-solids separation, and pathogen destruction in one unit operation.
PROGRESS: The general goal of this project, which began in 1976, has been to define the conditions which could enable development and implementation of simple, low-maintenance fermentation reactors. The latest phase of this project has centered around the following activities: (1) a side-by-side comparison of the operation of a conventional technology municipal digester and a low-cost simplified plug flow fermentor, both systems tested at varied HRT and at two temperatures, 25 degreees C and 35 degrees C; (2) operation of a pilot scale (5.6 m (3)) plug flow reactor on dairy cow manure while testing at various HRTs, bedding additions and at two temperatures (25 degrees C and 35 degrees C); (3) testing of a pilot scale (5.0 m (3)) cubical, limited mix reactor (random mix) at varied HRTs, bedding compositions in the feed and at 25 degrees C and 35 degrees C. This full scale demonstration of the feasibility of producing biogas on a small dairy operation is the first large scale, long term demonstration of this technology in the U.
SUPPORTED BY: New York State Government.

4.0101
HIGH TEMPERATURE STABILIZATION AND MOISTURE REMOVAL FROM ANIMAL WASTES FOR BY-PRODUCT RECOVERY
Jewell WJ, Dondero NC, Van Soest PJ, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123584)
OBJECTIVE: An ideal animal waste treatment and residue recovery system would convert obnoxious wet animal wastes to an odorless, stabilized, pathogen-free material with moisture content less than 40% in a simple process without addition to large amounts of energy. The goals of this study will be to determine the feasibility of developing such a process and to build a bench scale pilot unit process to demonstrate its potential.
APPROACH: The basic steps that will be utilized to meet the project goals are: determination of kinetics of organic carbon decomposition and oxygen transfer limitations in semi-solid animal wastes created by combining the treated and dried animal wastes with the wet raw wastes; determine the heat released during aerobic stabilization and identify means of conserving the energy to achieve autoheating of the organics; measure the rate of moisture removal from autoheated animal wastes; combine the above into a simple single unit pilot plant that would achieve high rate organic stabilization and simultaneous moisture removal; and determine, at temperatures of 60 to 70 degrees C, autoheating requirements to produce pathogen destruction, and maximum microbial production of protein.
PROGRESS: Aerobic oxidation of organics by microorganisms results in the release of energy in the form of heat. This project is being conducted to determine the feasibility of using this energy to stabilize animal wastes, parteurize them, and then use the remaining energy for moisture removal. For simiplicity, the process under development is referred to as the biodryer. Laboratory testing to define the fundamentals of high temperature semi-solid aerobic decomposition of dairy wastes has been completed. This information provided the basis for a design and operation of a small (20 liters per day feed rate) pilot reactor. Successful operation of the small pilot unit has led to the design and operation of a large pilot biodryer (1000 liters per day feed rate). Activities on the project have included asessment of the nutritional characteristics for consideration of refeeding the product, survey of pathogen survival, and a computer simulation of the process.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0102
ALCOHOL PRODUCTION FROM AGRICULTURAL BY-PRODUCTS
Jewell WJ, Zall RR, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123343)
OBJECTIVE: Determine the feasibility of applying a high rate biological process originally developed at Cornell to agricultural residues for ethanol production. This initial feasibility study will examine the feasibility of developing a strongly attaching, pure ethanol producing microbial population to small inert particles in an upflow "expanded bed" continuous flow reactor. Determine the potential of continuous removal of alcohol from the reactor. Determine the potential of continuous removal of alcohol from the reactor by vacuum distillation

measure the maximum concentration of ethanol in the product gases and describe the kinetics of microbial growth and ethanol production.
APPROACH: Two small laboratory expanded bed reactors will be operated for alcohol production from sugar beet molasses. Organisms that will be examined will be from several strains of yeast (S. cerevisiae) or bacteria (Clostritium thermocellum) that have been shown to be capable of high rates of ethanol producion. The initial feasibility testing will have a duration of six months. Successful development of this application will provide necessary information to justify additional scale-up and comprehensive testing.
PROGRESS: The overall goal of this study will be to determine the feasibility of applying a high rate biological process originally developed at Cornell to agricultural residues for ethanol production. This initial feasibility study will have as its objectives to: (1) examine the feasibility of developing a strongly attaching pure ethanol producing microbial population to small inert particles in an upflow "expanded bed" continuous flow reactor; (2) determine the potential of continuous removal of alcohol from the reactor by vaccum distillation; (3) measure maximum concentration of ethanol in the product gases; (4) describe the kinetics of microbial growth and ethanol production. Two small laboratory expanded bed reactors will be operated for alcohol production from sugar beet molasses. Organisms that will be examined will be from several strains of yeast (S. cerevisiae) or bacteria (Clostridium thermocellum) that have been shown to be capable of high rates of ethanol production. The initial feasibility testing will have a duration of six months. Successful development of this application will provide necessary information to justify additional scale-up and comprehensive testing.
SUPPORTED BY: New York State Government.

4.0103
HIGH RATE BIOLOGICAL PRODUCTION OF ALCOHOL FROM AGRICULTURAL BY-PRODUCTS
Jewell WJ, Zall RR, Bellamy WD, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123590)
OBJECTIVE: Evaluate new developments in ethanol production from agricultural residue that may significantly decrease production costs.
APPROACH: The research will focus on an evaluation of a new process, the attached microbial film expanded bed (AFEB) reactor. Additional components of this study will include unique ways of pretreating cellulose to make it more available, to use vacuum removal of alcohol to examine methods of controlling the fermentor levels to enhance microbial levels, and investigate methods of enhancing alcohol production using thermophilic bacteria and combinations of species.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0104
DEVELOPMENT, IMPROVEMENT AND UTILIZATION OF CHEESE, WHEY, AND FERMENTED MILK FOODS
Kosikowski FV, Dept. of Food Science, Cornell University, *Ithaca, New York, 14850,* (NYC-143432)
OBJECTIVE: Apply the ultrafiltration of skim milk and whole milk to developing new concepts of cheese and fermented milk manufacture; produce new and improved fermented milk foods, study flavor reactions and enzyme behavior, improve nutrition and safety of cheeses and related products and utilize whey in forms easily accepted by humans.
APPROACH: Initiate controlled pilot plant experiments involving ultrafiltration, ultradialysis, and vacuum concentration equipment and where results appear promising, to escalate studies on a commercial scale. Biochemical, flavor, and enzyme reactions will be conducted using sophisticated analytical equipment and leads obtained will be directed at pilot-plant scale studies.
PROGRESS: Applying mixed strains of yeast cultures to SCP from whey and petroleum substrates has led to increased efficiencies and improved product. The utilization of demineralized, ultrafiltrated acid whey concentrates by adapted lactose fermenting yeast have given alcohol levels above 10% and show promise in the production of gasohol. Supplementation of cheesemilks with approximately 5:1 concentrated whole milk and skim milk retentates of ultrafiltration has led to Cheddar and Cottage cheese of acceptable quality. For Cheddar cheese, volumes were increased significantly, rennet amounts were decreased by approximately 30% or more and cooking temperatures were reduced. For Cottage cheese volumes were also increased to high levels and length of cooking time was lowered. Cheese yield efficiencies for both cheeses appear to have attained higher levels than controls. Accelerated ripening through the addition of very small amounts of microbial or animal enzymes to Cheddar cheese curds with salt increased typical flavor without leading to defects. Standardization of critical enzyme levels and selection of effective enzyme types have resulted in better control of flavor development. Investigations in greater depth and expanded to industrial scale are underway on the supplementation of milk for Cheddar, Cottage, Mozzarella, and Ricotta cheese with whole milk and skim milk retentates to improve quality, efficiency, yields, and conserve energy.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0105
ENERGY IN ANIMAL MANURES
Sobel AT, Muck RE, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123422)
OBJECTIVE: Investigate the utilization of biologically released heat from animal manures for on-farm applications. Specifically investigate the effect of heat energy released from in-barn stored manure on the quality of the environment within the barn.
APPROACH: Agricultural by-products, animal manure being a specific example, represent a considerable quantity of energy. These by-products represent to the agricultural engineer a challenge to make use of this energy to supplement our dwingling and increasingly more costly energy sources. The purpose of this research project is to take an overall look at energy from animal manures with specific emphasis on utilizing biologically produced heat and to provide some basic concepts into the magnitude of heat energy available, the conditions favorable to its release, and potential means of utilizing this energy. A comparison of the various forms of energy will be made to determine the efficiencies of energy utilization systems.
PROGRESS: Available literature and current research projects are being reviewed to obtain parameters on the available energy and the release parameters for energy from animal manures. Supplemental information is being determined by experimentation on a pilot scale. A small feed mixer (17 cu. ft. capacity) has been adapted to serve as a calorimeter to determine the magnitude of energy available from high solid content (15-50% wet basis) manure under mixed and non-mixed conditions. The effect of residence time, bedding material, moisture content, and reaction temperature on heat energy release is being investigated. A mathematical model of in-barn manure storage for dairy animals will be established to predict the contribution of released heat to the environment of the barn. The existance of oxidation ditches in one part of the slatted floor free-stall barn at the T/R Center prevents the study of the barn as a single waste management system. However, the environment in the free-stall barn with a scraped alley system and in the section of the barn containing the in-barn storage will be monitored to establish conditions for comparison with the mathematical model. The temperature and humidity within the barns, including within the manure storages and the temperature and humidity outside the barn will be monitored for a period of time to cover seasonal variations. The manure from the systems will be monitored as to moisture content to determine evaporation loss.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0106
ALCOHOL PRODUCTION FROM SELECTED NEW YORK CROPS
Walker LP, Gunkel WW, Campbell JK, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123433)
OBJECTIVE: Develop a data base on availability of culled potatoes, apple peelings, plums, and cabbage trimmings. Assess the technical and economic feasibility of collecting raw materials and disposing of waste products generated in the production of alcohol. Establish data on enzymes and yeasts needed to convert raw materials to alcohol. Develop a small scale laboratory alcohol plant to determine potential of using above feedstocks for alcohol production.
APPROACH: Utilize data developed by local, state, and federal agencies. Interview extension personnel, producers, and processors. Determine whether current harvesting and processing techniques can be adapted to large scale biomass collection, and whether the by-products have value as feedstocks or soil conservation agents. If not, explore avenues of disposing of by-products with minimum environmental damage. Will review literature on enzyme and acid hydrolysis of proposed feedstocks, and the ability of various yeasts to convert sugar to alcohol. Will examine existing alcohol plant designs, and using mathematical modeling and optimization techniques, develop an "optimal" plant design to be used in building a pilot plant at Cornell.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0107
APPLICATION OF "RAPID FERMENTATION" TO THE PRODUCTION OF PRODUCTS FROM CELLULOSIC WASTES
Steinkraus KH, New York State Agricultural Experiment Station, *Geneva, New York, 14456,* (NYG23363)
OBJECTIVE: Apply the principles of "rapid fermentation" to the practical production of cellobiose and/or glucose from cellulosic substrates, particularly wastes such as straw, waste paper, and sawdust. Utilize the cellobiose/glucose directly in the manufacture of useful fermentation products.
APPROACH: Trichoderma viride, Cellulomonas sp. Myrothecium sp. Chaetomium sp. Neurospora crassa all cellulase producers, will be applied to crude cellulose substrates including straw, waste paper, and other cellulosic wastes. The "rate" i.e., the number of glucose molecules produced from the cellulose per cell (or per unit cell weight) per second will be determined. Then the number of cells required to produce the rate of reaction desired will be determined. Then the % of total available cellulose hydrolyzed in a given time interval will be determined. Present processes for cellulose hydrolysis require generally several days making the use of cellulose rather impractical. Initially, the objective will be to reduce fermentation time to less than 24 hours and then to reduce the total time required to 10 hours or less.
PROGRESS: Pleurotus ostreatus, the oyster mushroom, was grown on sterilized hydrated corn kernels, rice, and wheat to produce a spawn. It was then inoculated on a ligno-cellulosic medium made from shredded newspaper or shredded computer paper. The shredded paper was thoroughly hydrated in an excess of water and then drained. It was fortified by addition of 5 to 10% wheat bran and 5% CaCO(3). Some samples were also fortified by addition of 5% oat kernels or urea (0.2%) added as an inorganic nitrogen source. The ligno-cellulosic substrates were sterilized in steam, colled, and inoculated with spawn (5% w/w). Incubation temperatures used ranged from 25 to 30 degrees C. Fresh mushroom yields as high as 50% of the original dry weight of ligno-cellulose have been achieved.
SUPPORTED BY: New York State Government.

4.0108
PARAMETRIC ANALYSIS SUPPORT TO THE ALCOHOL FUELS PROCESS DEVELOPMENT ACTIVITIES
Morriss FV, Chemical Systems Inc., *New York, New York, 10017,* (XK 0 9308 01)
OBJECTIVE: The objective is to provide parametric analysis support to the Alcohol Fuels Process Development Activities.
APPROACH: The first task is to prepare a full definition of a prototype process using corn stover as the basic raw material. The process will be defined by identification of all equipment and process steps necessary to convert the corn stover to anhydrous ethanol. The initial reactor design con-

cept will consider updated Madison process which used dilute sulfuric acid percolated through a bed of corn stover. Provision will be made for raw material storage, handling, and pretreatment of the stover, and equipment for neutralization of the open acid with lime, evaporation of the sugar solution to a suitable concentration for fermentation, fermentation, and then distillation to recover anhydrous alcohol. The waste lignin and unconverted corn stover will be disposed of as a fuel to generate process heat. A continuous process sequence, as described above, is likely to be appropriate for the large plants, 50 and 10 MM gal/yr, but the smaller plants, 2MM and 250,000 gal/yr, will probably require a separate process definition, because continuous operations may not be economical. Multiple hydrolysis reactors and elaborate solids conveying equipment may not be required. It may be possible to simplify the requirements for fermentation and distillation if storage of intermediate products is feasible. An evaluation of continuous versus batch operations along with storage requirements for these smaller plants will be made. The second task is to prepare process flowsheets in sufficient detail to ensure that all process equipment requirements have been included. The third task is to develop a computer simulation of the process design and economics so that parametric case studies can be performed in a consistent and cost-efficient manner.
SUPPORTED BY: U.S. Dept. of Energy.

4.0109
ANIMAL WASTE UTILIZATION AND TREATMENT SYSTEMS
Westerman PW, Overcash MR, Goode L, Dept. of Biological & Agricultural Engineering, North Carolina State University, *Raleigh, North Carolina, 27600,* (NC01144)
OBJECTIVE: Utilize animal wastes as feed and source of methane, determine responses in soil-plant-water systems when animal wastes applied, and optimize waste treatment processes and management techniques. Develop data and models to choose among alternative waste management components.
APPROACH: Animal wastes mixed in feed rations, ensiled, evaluated for composition and digestibility, used in feed trials. Selection of methanogenic cultures and construction of pilot scale methane reactor for poultry wastes, field and lab studies and literature review of animal waste land application, lagoon studies for swine and poultry manure, analysis of economic and performance data for waste management systems.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0110
THERMOPHILIC METHANE PRODUCTION FROM POULTRY WASTE
Shih J, Dept. of Poultry Science, North Carolina State University, *Raleigh, North Carolina, 27600,* (NC03605)
OBJECTIVE: Isolation and selection of a methanogenic bacterial culture in a poultry waste-based medium at thermophilic temperatures; adaptation of the methanogenic culture to a highly efficient methane producer and chemical analyses to fully characterize the wastes, the gas products, and the effluents from the reactor.
APPROACH: A number of cultures of thermophilic bacteria will be screeened to identify the strains that have the capability of producing large volumes of methane from poultry waste. Preliminary laboratory studies will be conducted to purify the strains and perfect the methane generation.
PROGRESS: Thermophilic anaerobic digestion for the bioconversion of broiler chicken litter into methane was first investigated. The methanogenic cultures were initiated from the incubation of marine salt marsh, rumen fluid, or pond mud with the medium containing the waste. Since their rates of gas production were not significantly different, all cultures were mixed to maintain the genetic pool. At 60 degrees C and neutral pH, the mixed culture was challenged with various retention times (RT) and feeding concentrations to delineate the biological potential for methane production as well as for volatile solids (VS) degradation. At feeding concentration 7% VS and RT from 3 to 10 days, methane was produced from 0.32 to 0.23 1/1/day and VS degradation from 16.4 to 20%. At 5-day RT and concentration from 3 to 9% VS, methane was produced from 0.20 to 0.35 1/1/day and VS degradation from 23.1 to 13.9% VS. The relative low rates of methane production and VS degradation from the broiler litter are believed to be due to the high proportion of wood chips and aging of the litter. More recently, similar experiments were conducted to study the waste of laying hens. Preliminary results indicated a high methane potential from the layer manure.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0111
POTENTIAL FOR PROCESSING OF NORTH DAKOTA AGRICULTURAL PRODUCTS
Mittleider JF, Zetocha DF, Dunn EV, Dept. of Agricultural Economics, North Dakota State University, *Fargo, North Dakota, 58103,* (ND01367)
OBJECTIVE: Identify and screen potential agricultural processing activities in North Dakota based on technical and economic feasibility. Determine the economic feasibility of processing and marketing agricultural products produced in North Dakota. Determine the feasibility of utilizing various agricultural products and agricultural by-products produced in North Dakota as alternative energy sources.
APPROACH: Possible development opportunities will be identified and screened through contacts with university researchers, industry representatives, commodity groups and state and federal agency representatives. Preliminary screening research activities will be carried out on those commodities that are the most promising in terms of technical and economic feasibility and in terms of the impact on the state's economy. The supply of the commodity required, investment and operating costs, and market locations and access will be analyzed. Information will be obtained from primary and secondary sources, including universities, relevant industries, crop and livestock producers, state and federal agencies, public companies, and public and private development organizations. The potential of methane, alcohol and gasohol derived from agricultural products or by-products will be analyzed using the same appraoch, method of analysis and sources of information as outlined in Procedures 1 and 2.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0112
BIOMASS UTILIZATION AS AN ENERGY SOURCE
Lindley JA, Backer LF, Johnson R, Dept. of Agricultural Engineering, North Dakota State University, *Fargo, North Dakota, 58103,* (ND01438)
OBJECTIVE: Evaluate systems for collecting residue from field crops. Evaluate systems for densification of biomass. Evaluate systems for the direct combustion and gasification of biomass. Determine the economics and energy balance of collecting and utilizing biomass. Review availability of biomass residue and impact of removal in North Dakota.
APPROACH: Various methods for collecting sunflower residue will be tried. Evaluate successful methods in terms of time, energy, and residue collection efficiencies. Evaluate parameters affecting briquetting. Review potential of other methods of densification. Review combustion process and select appropriate technology for direct combustion of biomass. May design and construct new system. Determine optimum biomass form and evaluate combustion of biomass as a method or providing on-farm energy. Determine the economic of the various steps from residue removal to energy utilization. Review literature and data from agronomy and soils to predict quantities of residue produced and available for use as an energy source.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0113
SUNFLOWER OIL AS AN ENGINE FUEL
Pratt GL, Kaufman KR, Kucera HL, Dept. of Agricultural Engineering, North Dakota State University, *Fargo, North Dakota, 58103,* (ND01439)
OBJECTIVE: Develop a system for small scale extraction of sunflower oil. Determine physico-chemical properties of sunflower oil and sunflower oil-diesel fuel mixtures relating to use as fuels for diesel engines. Determine performance of farm sized diesel engines when using sunflower oil-diesel fuel blends. Determine economic feasibility and operating costs for small scale sunflower processing units.
APPROACH: Emphasis will be on development of a small scale expeller system to extrude sunflower oil for fuel. Sunflower oil alone and blended with diesel fuel will be analyzed to determine conformity with industry standards. If not satisfactory, efforts will be made to correct the deficiency. Particular emphasis will be on storage. Tests will be conducted to determine operation and performance of farm diesel engines using sunflower oil-diesel fuel blends. Efforts will be made to evaluate economic feasibility and operating costs.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0114
HYDROGEN-PRODUCING BACTERIA IN ANAEROBIC WASTE TREATMENT
Holmes PE, Dept. of Bacteriology, North Dakota State University, *Fargo, North Dakota, 58103,* (ND01811)
OBJECTIVE: Identify hydrogen-producing bacteria in anaerobic waste treatment, define parameters affecting hydrogen-producing bacteria, and determine the importance of hydrogen-producing bacteria in anaerobic waste treatment.
APPROACH: In situ rates of hydrogen generation and turnover will be estimated as a function of factors known to influence waste treatment. Direct isolation and characterization of anaerobic bacteria from wastes being treated anaerobically. Ability to produce hydrogen will be assessed, using growth conditions that closely simulate the habitat of an anaerobic digester. Parametric study of pure culture isolates that will consider factors known to influence anaerobic treatment. Such parameters will include pH, temperature, substrate types and concentrations, oxygen and redox potential, organic and inorganic substances other than substrates, and components of the waste.
PROGRESS: The occurrence of active hydrogen (H(2))-producing bacteria in hog waste undergoing anaeobic digestion at low temperature (4 degrees C) was found to be very low, as was the entire digestion process. None of the isolates from these digesters were found to make H(2) when selection was for strains able to grow in complex media at 4 degrees C. Since the digesters are only 1 1/2 years old and not fully adapted yet to operation at 4 degrees C, these results may change. Procedures are being developed to increase the rate of culture purification to facilitate this work.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0115
PSYCHROPHILIC ANAEROBIC WASTE TREATMENT IN NORTHERN CLIMATES
Holmes PE, Dept. of Bacteriology, North Dakota State University, *Fargo, North Dakota, 58103,* (ND05080)
OBJECTIVE: Seasonal effects on occurrence and activity of psychrophilic and psychrototrophic bacteria in anaerobic waste lagoons; parameters of growth and activity of psychrophilic and psychrotrophic anaerobic bacteria; study laboratory scale low temperature anaerobic digesters; determine effectiveness of seeding conventional lagoon models with psychrophilic and psychrotrophic anaerobic bacteria in relation to operating temperature; assess potential for methane recovery from low temperature anaerobic lagoons.
APPROACH: Lagoon samples are cultured directly on selective and non-selective media at various temperatures to assess numbers and types of bacteria and correlated with physical-chemical parameters of the lagoon. The Hungate anaerobic technique will be used. Isolates with temperature optima below 20 degrees C will be further characterized, laboratory scale digesters will be discontinuously fed typical lagoon feed and operated at various temperatures. Seeding studies will monitor methanogenesis, waste turnover and

seed growth. Zero-time rates of methanogenesis will be used to assess potential for methane production and digestion rates.
PROGRESS: Temperature optima for anaerobic digestion of hog waste in digesters operated continuously at 4 degrees, 15 degrees, and 25 degrees C was found to be dependent on digester age, retention time and temperature. The complex interaction results in part from the fact that the digesters operated at 4 degrees C have not yet adapted to that temperature and are not in steady state. Cultures of bacteria with temperature optima near 20 degrees C were isolated on complex media from a digester operated 1 1/2 years at 4 degrees C. They are unable to grow above approximately 30 degrees C and resemble members of the genus Bifidobacterium. No colonies appeared in the same media at 4 degrees C when inoculated from similar digesters operated at 25 degrees C. These results indicate temperature adaptation of the 4 degrees C digesters may be occurring.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0116
FULL SCALE FIELD DEMONSTRATION OF UNHEATED ANAEROBIC CONTACT STABILIZATION
Sykes RM, Dept. of Civil Engineering, Ohio State University, *Columbus, Ohio, 43212*, (AC02-80CS24310)
OBJECTIVE: The proposed research has two objectives: (1) to demonstrate the feasibility of unheated anaerobic contact stabilization of municipal sewage sludges in full-scale field digesters; and (2) to develop the design and operating data required to convert existing municipal digesters to this process. The expected benefit of this research is the doubling or tripling of the net gas production of municipal digesters, which would make sewage treatment plants energetically self-sufficient. Preliminary analysis indicates that conventional digesters can be converted to the contact-stabilization process at minimal cost (only some pumps and piping are needeed). Furthermore, it is expected that the proposed technology can be applied to other methane fermentations, e.g., of cattle manure. The proposed research differs from previous studies of anaerobic contact stabilizatiion in two ways: (1) the proposed research will use cold rather than heated digesters (to save gas); and (2) it will use full-scale field installations rather than laboratory and pilot plants (thereby avoiding the scale-up problem). The final product will be a report detailing the design criteria and operating methods needed to implement unheated anaerobic digestion at existing municipal wastewater treatment plants.
SUPPORTED BY: U.S. Dept. of Energy.

4.0117
FARM ETHANOL PRODUCTION DEMONSTRATION
Longbrake W, Ohio State University Research Foundation, *Columbus, Ohio, 43212*, (FG02-80R510244)
OBJECTIVE: The production of ethanol from farm products will be demonstrated.
SUPPORTED BY: U.S. Dept. of Energy.

4.0118
SUNFLOWER OIL AS A DIRECT, LIQUID, AGRICULTURAL FUEL IN THE EASTERN CORN BELT
Roller WL, Triplett GB, Henry JE, Dept. of Agricultural Engineering, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691*, (OHO00301-SS)
OBJECTIVE: Conduct an engineering feasibility study of the production, processing, and utilization, on a community cooperative scale, of sunflower oil (SFO) as a direct fuel for diesel engines on agricultural machines.
APPROACH: Determine the culture and energy efficiency of an adapted oil variety of sunflower, when grown strictly as a fuel double-crop in Ohio. Determine the process procedures, oil yields and energy inputs for the extraction of the oil by mechanical, thermally-unsophisticated technology. Determine the power yield characteristics of mechanically extracted semi-refined SFO when used in diesel engines. Perform an engineering analysis of feasibility with respect to energy yield ratio, management skills, equipment availability, capital, and labor requirements, in conjunction with studies started elsewhere in the North-Central region recently.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0119
CONTINUOUS COOKING AND SACCHARIFICATION OF AGRICULTURAL GRAINS IN PRODUCTION OF FUEL ALCOHOL
Clary BL, Whitney RW, Downs HW, Dept. of Agricultural Engineering, Oklahoma State University, *Stillwater, Oklahoma, 74075*, (OKL01779)
OBJECTIVE: Develop continuous flow cooking processes to solubilize starches in agricultural grain. Evaluate fluid viscometric (viscosity and density) properties of solubilized grain products as a function of time and water content during cooking and saccharification. Develop continuous flow saccharification processes for fuel alcohol production from agricultural grains.
APPROACH: Performance of the Brady Extrusion cooker in gelatinizing grain starches will be evaluated by dissolving extrusion cooked grain in water, adding amylase enzymes for conversion of starch to sugar and fermenting to determine ethanol production from extrusion cooked grain. The Brookfield and McMichael viscometers will be utilized in evaluating viscometric properties of grain starches during cooking and saccharification.
SUPPORTED BY: Oklahoma State Government.

4.0120
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
Koelliker J, Willrich TL, Wensink RB, Dept. of Agricultural Engineering, Oregon State University, *Corvallis, Oregon, 97331*, (ORE00116)
OBJECTIVE: Conceptualize, develop, analyze, and optimize animal manure management systems with least cost and energy requirements for pollution control compatible with changing socio-politico-economic patterns. Develop optimal animal manure management systems; characterize atmospheric contaminants and develop abatement methods; investigate use of manure management systems by-products for energy sources, feed ingredients, plant nutrients; characterize the non-point pollution sources.
APPROACH: An integrated hydraulic swine manure transport and management scheme will be developed, which involves separation of solids from a swine manure slurry, anaerobic digestion of the solids, growth of algae on the liquid fraction, and re-use of the water for manure transport. Algae will be the livestock feed ingredient. Computer simulation models will be used to develop design procedures for control of runoff from cattle feedlots. The production, evolution and transport of gaseous by-products of manure decomposition will be studied.
PROGRESS: Naturally occurring zeolite materials were evaluated for use in improving the air quality within confinement buildings. When applied directly to the letter, up to 35% reduction in ammonia concentration was achieved along with a reduction of footpad bum from 53 to 10%. When used as packing in a scrubbing device, ammonia concentration reductions between 20 and 40% were achieved along with some odor removal. The economic component of the feedlot runoff pollution control model was completed and applied to various sites around the U.S. A model for predicting runoff and retention basin quality was formulated based upon lot characteristics and climatic data. Data were collected at a feedlot site in Central Illinois with which to calibrate the model. A cross flow air scrubber was designed, built and tested for removing odor and particles from a swine confinement building atmosphere. Water in a cross flow configuration was the scrubbing medium. Over 90% removal of particles five microns and larger in diameter was achieved.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0121
A WASTEWATER REUSE SYSTEM FOR HYDRAULICALLY FLUSHED DAIRY BARNS IN HIGH WINTERTIME RAINFALL AREAS
Miner JR, Moore JA, Swanson L, Dept. of Agricultural Engineering, Oregon State University, *Corvallis, Oregon, 97331*, (ORE00903)
OBJECTIVE: To develop a wastewater reuse system compatible with flushed alleys in a modern dairy facility. To document the performance of such a system in terms of labor requirements, energy consumption, and plant nutrient conservation. To stimulate related research efforts including solids utilization, single cell protein recovery, odor control, methane production, and equipment improvement.
APPROACH: A dairy wastewater system consisting of a solid-liquid separator, solids storage shed, liquids storage tank, aeration tank, and the necessary appurtenance will be installed and evaluated.
SUPPORTED BY: Oregon State Government.

4.0122
RELATIONSHIP OF AQUATIC FLORA TO WATER QUALITY AND POLLUTION
Phinney HK, Dept. of Botany & Plant Pathology, Oregon State University, *Corvallis, Oregon, 97331*, (ORE00275)
OBJECTIVE: A continuing research program concerning the relationship of awuatic flora to quality of water supplies and to water pollution. Determine, by biological studies of aquatic habitats, relationships between biotic and edaphic factors that determine change in quality of water resources. Coordinate and extend the botanical phases of studies presently being conducted or planned in the general area of aquatic botany.
APPROACH: A basic three-pronged approach will be continued: Study, in the field, of aquatic biological problems, attempting to relate the biotic and abiotic factors; laboratory studies of the fundamental autecology of plant species that are important in the aquatic environment and field and laboratory studies of the biological interactions of species known to regularly co-occur in problem situations. Obviously in one problem situation more than one of these methods might be used.
PROGRESS: The project studying cultural requirements of the hydrocarbon producing alga Botryococcus braunii continues to progress slowly. We have been able to reduce the generation time (time required to double the cell number) from seven days to a little more than five days by manipulating culture conditions. Trials of various different formulations of the culture medium continue. We hope to have some additional definitive results by 1 July 1979. We have begun some initial studies of the question of the causes of the occasional collapse of algal populations growing in and supporting the oxidative capacity of sewage oxidation ponds. Our hypothesis is that bacterial pathogens are responsible for the collapse at least on some occasions. An application for support under the appropriate technology program of the Department of Energy is planned. This problem was the cause of some of the problems experienced during the study of the use of algal mass cultures in the management of swine manure for the recovery of protein and biogas in which I collaborated with Boersma, Miner, Oldfield and Cheeke.
SUPPORTED BY: Oregon State Government.

4.0123
BIOGAS PRODUCTION FROM ANAEROBIC DIGESTION OF ANIMAL MANURE
Persson SP, Walton HV, Bartlett HD, Dept. of Agricultural Engineering, Pennsylvania State University, *University Park, Pennsylvania, 16802*, (PEN02345)
OBJECTIVE: Determine the effects of operational and environmental factors on methane production by anaerobic digestion of animal residue at raised temperatures.
APPROACH: The 100 m anaerobic digester developed for studies on methane generation from dairy manure will be operated to determine the effects of the following on biogas production rate and quality. Recycle liquid separate from digester effluent as dilution water. Use of milking center wastewater for dilution water. Pretreat poultry manure to reduce ammonia concentration.

Develop automatic controls for reduced labor. Conduct tests of biogas as combustion engine full.
PROGRESS: The full-scale (100 m) dairy manure anaerobic digester was operated from March to November. Slurry input by conveyor near the top of the digester substrate showed no reduction in biogas production efficiency. The conveyor feed method is lower in capital cost than the ram-pump. Addition of milking center wastewater (milk solids, detergents and sanitizing compounds) as digester input dilution water did not show adverse effects on gas production. Dewatering digester effluent (11.2% TS) with a manure solids separator resulted in a fibrous component with 34% TS (db) and liquid component with 5.4% TS (db). Recycling the liquid as dilution for digester input slurry to recover heat produced a 6 C increase in input slurry temperature. Biogas as fuel for a 1.1 liter displacement spark-ignition engine produced up to 80% of the power of the same engine on gasoline. The fuel equivalent was approximately 1.65 m biogas per liter of gasoline. Operating the engine at 10kW output and 1900 rpm consumed gas at the same rate as it would be produced by a 100 cow digester, but produced considerably more cooling water heat than needed for heating the digester. Inhibiting effects of high ammonia levels on biogas production in laboratory scale poultry manure anaerobic digesters were reduced by washing the input manure; gas output was increased more than 20%.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0124
A STUDY OF THE CONVERSION OF AGRICULTURAL WASTES TO LIQUID FUELS
Felbeck GT, Dept. of Food Science & Technology, University of Rhode Island, *Kingston, Rhode Island, 02881,* (RI00301)
OBJECTIVE: Determine by means of simulation experiments the naturally occurring conditions under which various organic materials could be converted to hydrocarbons. Apply the results of these experiments to the problem of geochemical prospecting for oil with particular emphasis on increasing the efficiency of drilling productive wells. Apply the processes developed to the conversion of agricultural waste materials to liquid fuels.
APPROACH: A matrix of organic and inorganic materials, blended to simulate marine sediment mixtures will be subjected to appropriate laboratory conditions to simulate reaction times of up to 10 years at 100 degrees C. Reaction products will be compared with crude oil hydrocarbons to test process validity. The catalytic action of various metal compounds will be evaluated.
PROGRESS: A laboratory procedure has been developed for the generation of gaseous alkanes from various biologically-derived precursors (carbohydrates, lignins, proteins, and lipids). The process involves heating the precursor, reduced vanadium oxides, nickel sulfide, ammonia, and water in an autoclave for 15 hours at 440 degrees. The maximum yield obtained to date is about 50% on a carbon-carbon basis from cellulose. The product consists of all possible alkanes from methane to cyclopentane except for 2.2-dimethyl propane. The apparent activation energies for this reaction were calculated over the reaction temperature range of 300 to 475 degrees. At the higher temperatures (above 410 degrees) the apparent activation energy was about 51 kcal/mol, which suggests that the primary reaction was pyrolytic decomposition of cellulose. However, at the lower temperatures (below 400 degrees), the apparent activation energy was calculated to be about 22 kcal/mol, suggesting that the reaction in this range was primarily catalytic. Further support for the catalytic theory was obtained by observing that repeated use of the catalyst (up to six reuses) in the reaction produced only a slight reduction in the yield of gaseous alkanes from cellulose. Along with the gaseous products, a dark-brown hexane-soluble oil was obtained from the cellulose reaction. Fractionation of this liquid indicated that it contained alkanes, cycloalkanes aromatic compounds and a polar fraction.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0125
SWEET POTATO BIOMASS PRODUCTION RESEARCH
Hamilton MG, Jones A, Edisto Experiment Station, Clemson University, *Blackville, South Carolina, 29817,* (7006-20020-009-A)
OBJECTIVE: Determine the maximum yield potential in total biomass and fermentable carbohydrates of sweet potato.
APPROACH: Tests of three planting dates using transplants and one direct seeded with precut seed pieces will be conducted. Yields in terms of total biomass and fermentable carbohydrates will be determined from each test. One test will be grown under irrigation to evaluate tolerance of cultivars to root rotting in wet soils. The direct seeded test will evaluate the yield potential of cultivars using that system of planting which would greatly reduce energy requirements for sweet potato production for total biomass. Laboratory tests will be made to determine the biochemical requirements for ethanol production from sweet potato roots.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

4.0126
ANIMAL WASTE UTILIZATION AND TREATMENT SYSTEMS
Hegg RO, Barth CL, King TG, Dept. of Agricultural Engineering, Clemson University, *Clemson, South Carolina, 29631,* (SC00398)
OBJECTIVE: Determine optimum harvesting, storing, and processing procedures in utilizing animal wastes as feedstuffs, sources of energy and culture media and determine the response of animals to diets containing animal waste products and process by-products. Determine biological and chemical responses that occur in the soil, plant, and hydrologic systems when animal wastes are applied to the major soil types of the region. Optimize waste treatment processes and management techniques to minimize energy requirements improve utilization and enhance management efficiency, and evaluate methods of improving air and water quality in systems which recirculate waste water.
APPROACH: South Carolina approaches will include: combining cage-layer manure and dry feeds for ensiling and recycling through steers, application of swine lagoon effluent onto pine or hardwood forest, overland flow treatment of beef feedlot runoff, land application of animal manure, and analysis of animal waste lagoons for utilization of the liquids and sludges.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0127
ETHANOL PRODUCTION AND ENERGY EFFICIENCIES FOR ON-FARM FUEL PRODUCTION
Roberts DL, Dodd RB, Dept. of Agricultural Engineering, Clemson University, *Clemson, South Carolina, 29631,* (SC00429)
OBJECTIVE: Design and construct prototype on-farm ethanol still with flexibility to investigate ethanol production and energy efficiencies in handling and preparing raw materials and utilizing renewable energy sources to provide process heat. Conduct laboratory tests to determine efficient starch-to-sugar conversion and fermentation procedures that are practical for use in the on-farm still. Determine efficient procedures for producing hydrated ethanol of desired proof levels and for handling the feed co-product.
APPROACH: Construct a mobile ethanol plant with technology and equipment suited to on-farm operation. Experiment with this prototype unit to determine inefficiencies in feedstocks preparation and conversion to ethanol. Laboratory studies will evaluate present procedures being recommended and will test modified procedures to improve these efficiencies and be most compatible to on-farm production. Equipment modifications will be made for heat recovery and improving boiler operations using renewable energy sources to minimize process energy required for distillation and feed co-product drying.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0128
WORKSHOP ON BIOMASS CONVERSION IN SUGAR DOMINANT ECONOMIES: THE TECHNICAL ASSESSMENT, SOCIO-ECONOMIC AND ENVIRONMENTAL ISSUES
Unknown, Graduate School, University of South Carolina, *Columbia, South Carolina, 29208,* (008404)
OBJECTIVE: The project consists of a workshop on biomass conversion in sugar dominant economies, including technical assessment and socio-economic and environmental impact issues.
SUPPORTED BY: U.S. Dept. of Energy, Office of Environment.

4.0129
FEEDING VALUE OF HIGH MOISTURE CORN PRESERVED BY DIFFERENT METHODS FOR DAIRY CATTLE
Voelker HH, Schingoethe DJ, Dept. of Dairy Science, South Dakota State University, *Brookings, South Dakota, 57006,* (SD00229)
OBJECTIVE: Compare dry shelled corn (DSC) with high moisture shelled corn (HMSC) from oxygen-limiting storage for dairy cows. Compare DSC with HMSC preserved with propionic acid in plastic lined cribs for dairy cows. DSC will be compared with corn by-product of gasohol production. Compare DSC with high moisture ear corn preserved with propionic acid in slat cribbing. Determine response of high genetic cows to high moisture corn using the best method of preservation from above objectives.
APPROACH: Corn silage and alfalfa haylage will be preserved in upright silos. Dry shelled corn will be compared with methods in objectives for preserving corn. Feeding experiments involving ten cows per group will be conducted measuring response to high moisture corn in oxygen-limiting storage, dry corn, corn preserved as shelled, and ear corn, treated with propionic acid. Highest producing cows in early lactation of high genetic groups of cows will be used. Measurements will include milk produced, fat, protein, and total solids, cow weights, dry matter intake, feed composition, and digestibilities, and preservation efficiencies. DSC and corn gasohol residue will be fed comparatively.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0130
PRODUCTION OF ALCOHOL FUELS FROM LIGNOCELLULOSIC CROP RESIDUES AND DAMAGED CEREAL STARCHES
Middaugh PR, Dept. of Microbiology, South Dakota State University, *Brookings, South Dakota, 57006,* (SD00885)
OBJECTIVE: Use the existing pilot plant to determine the actual production costs of producing 190 proof (95% alcohol fuel and the net energy balance of producing a gallon of fuel alcohol as a farm and community scale plant using corn and grains, especially damaged and high moisture crops, and the recovery costs for concentrating the by-product high protein animal feed for wet feeding of livestock.
APPROACH: Use newly developed technology for determining the cost of fuel alcohol per gallon and the input-output net energy balance for conversion of cellulosic crop residues including farm crop residues, straws, corn stover, sawdust, beet pulp, etc. For communities, determine the cost of converting land-fill plugging waste proper and materials such as elevator grain dust to fuel alcohol. Perfect and determine the cost of producing cellulase enzymes to carry out the cellulose conversions to sugars and to fuel alcohol for objective 2. Commercial cellulose is available at a prohibitively high cost. The experiments would be statistically designed and evaluated.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0131
FUEL ALCOHOL PRODUCTION BY AN OPERATING FARM SCALE PLANT: A COST AND ENERGY STUDY
Westby CA, Chisholm TS, Dobbs TL, Dept. of Microbiology, South Dakota State University, *Brookings, South Dakota, 57006,* (SD00350)

OBJECTIVE: Make a multidisciplinary study of the actual, existing, operating farm scale fuel alcohol production plant at South Dakota State University to determine the actual cost of constructing and operating a farm scale alcohol plant, the net energy balance and the net cost of the fuel alcohol per gallon and the cost of the animal feed co-product.
APPROACH: Determine the cost and energy balance required to produce a gallon of 95% fuel alcohol; determine the feasibility of using 95% and lower percentage of alcohol in farm equipment; evaluate engines using various gasoline-alcohol mixtures and problems related to phase separation; determine animal feed characteristics of the stillage feed product and prepare an economic analysis of construction, operation and investment return on a farm scale plant.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0132
RECOVERY OF ETHANOL FROM FERMENTATION BROTHS USING SOLVENT EXTRACTION GAS STRIPPING OR SORPTION TO REPLACE DISTILLATION
Pitt WW, Lee DD, Oak Ridge Operations Office, U.S. Dept. of Energy, Oak Ridge National Lab., *Oak Ridge, Tennessee, 37830*, (W-7405-ENG-26)
OBJECTIVE: The use of selective separation methods for removing ethanol from fermentation broths to immiscible solid, liquid, or gaseous phases can result in considerable energy savings over the conventional distillation methods. Ethanol is a liquid fuel used to make gasohol, a 10% ethanol-90% gasoline automobile fuel, and can be produced from abundant renewable resources by fermentation. A dilute (4 to 10%) ethanol-in-water solution is produced which is concentrated by distillation and azeotrophic distillation to anhydrous ethanol. The distillation steps may consume up to 40% of the heating value of the ethanol produced and use fossil fuel (No. 6 fuel oil) to provide heat. This task addresses the development of new technology to produce anhydrous ethanol using much less energy than distillation now uses. The methods to be studied are: solvent extraction, gas stripping, and adsorption. When suitable solvents or adsorbents are found (scouting tests have disclosed several candidate solvents and adsorbents), process flowsheets will be designed to enable material and energy balances to be calculated. The goal of the task is to find an economical and energy and material efficient method of producing a liquid fuel and chemical feedstock in pure form from renewable resources.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

4.0133
ENERGY UTILIZATION AND EFFICIENCY IN AGRICULTURE
Lepori WA, Lacewell RD, Dept. of Agricultural Engineering, Texas A & M University, *College Station, Texas, 77843*, (TEX06123)
OBJECTIVE: Identify present energy utilization and future needs for specific products of the Texas Agricultural Industry. Analyze methods to conserve the use of energy in present agricultural practices. Develop improved production and processing practices to reduce high energy consuming operations. Develop alternative sources of energy for agriculture.
APPROACH: Mass and energy flow models will be developed for individual products using network theory or similar techniques. Various production scenarios will be hypothesized and tested with the models to determine potential energy conservation practices. Alternative practices will be developed and new research proposed where high energy consuming operations are found. Economic implications of the production scenarios will be investigated.
PROGRESS: A concentrated effort has been placed toward developing appropriate technology to use agricultural residues and wastes as energy for Texas farms. Cotton gin waste was collected weekly from six gins in Texas during the 1977 ginning season. Chemical and other analysis were made on each weekly sample. The average percentages for all gins on a dry basis can be summarized from an engineering use standpoint as follows: volatile matter - 85%; carbon - 42%; hydrogen - 5.4%; nitrogen - 1.4% sulfur - 1.79%; arsenic - areas applying desiccants, .02% -areas not applying desiccants, 0.001%; oxygen and error-34.5%. Components of the trash samples were: lint - 11%; burs - 49%; sticks - 8%; and fines - 32%. Ash melting point was found to be between 1200 degrees C and 1258 degrees C. Moisture content of samples varied from 7.3% to 19.6% and gross heat value of the as received samples average 15.5 MJ/kg. Samples of sorghum residue have also been collected but analyses are not complete. Irrigated agriculture in Texas remains vulnerable to increasing fuel prices and threat of natural gas curtailments. Irrigation pumping plant efficiency testing has continued in cooperation with Texas Agricultural Experiment Station to generate base data for analyzing and demonstrating conservation potential.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0134
SYSTEMS ANALYSIS OF COTTON GIN TRASH UTILIZATION ALTERNATIVES
Parnell CB, Dept. of Agricultural Engineering, Texas A & M University, *College Station, Texas, 77843*, (DAR77-21292)
OBJECTIVE: The objective of this research is to develop a systems engineering model structured to permit the quantification of the energy, economic, and environmental costs associated with utilizing cotton gin trash. Alternatives to be studied include utilization as a cattle feed, as compost material, and as an energy source. The model will be used to determine the best alternative for gins processing picked and stripped cotton at rates of 10, 15, 20, and 50 bales per hour. Project results are expected to be useful in developing conceptual designs of systems for the safe utilization of cotton gin trash at minimum cost with acceptable rates of return on equipment and process investments.
PROGRESS: During the initial period, cotton gin trash samples were collected, experiments on fluidized bed gasification and composting have been started and joint feasibility studies with Southwestern Public Service and Weyerhauser Company have been negotiated to examine gin trash as a supplementary fuel and as a composting material.
SUPPORTED BY: U.S. National Science Foundation.

4.0135
ENGINEERING SYSTEMS AND ENERGY NEEDS FOR COTTON PRODUCTION
Parnell CB, Grubaugh EK, Dept. of Agricultural Engineering, Texas A & M University, *College Station, Texas, 77843*, (TEX03341)
OBJECTIVE: Improve energy management strategies for environmentally and economically - acceptable cotton production systems. Apply engineering systems to the development of decision-making models for cotton production.
APPROACH: A systems engineering study of utilization alternatives of cotton gin trash to include use of gin trash as a source of biomass energy, compost, cattle feed, and particle board will be pursued. This study will include a cotton gin simulation model designed to predict energy consumption as a function of ginning rate and trash content of cotton processed. Cotton dust studies will include evaluations of engineering dust controls for cottonseed oil mills.
PROGRESS: Aproximately 90 percent of the Texas cotton crop is harvested using mechanical strippers which results in an average of 454 kilograms (1000 lbs) of gin trash per bale that must be removed from the gin premises in order to maintain processing capability. Cost of handling gin trash has been estimated to be $2 to $4 per bale. Texas production of 4,000, 000 bales requires disposal of aproximately 1,800, 000 tons of gin trash. This project is being pursued with Horticulture, Forestry Science, and Industrial Engineering cooperating with the Agricultural Engineering Department. A 12-inch diameter fluidized bed gasification unit is being assembled for the study of gasification of gin waste as an energy source. A variety of vegetable and ornamental plants are being grown in peat moss-vermiculite gin trash compost growth media to study the utilization of gin trash compost as a replacement for peat moss and to determine the arsenic sensitivity of various plants. A joint study on the has begun with Southwestern Public Service Company. A similar agreement to study cotton gin trash as a replacement for peat moss and tree bark in nurseries is being worked out with Weyerhaeuser Company. Project personnel are in the process of structuring a simulation of the cotton production and processing system to include a cotton ginning simulation that will be used as a basis for the systems analysis of cotton gin trash utilization alternatives.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0136
QUALITY FACTORS IN SORGHUM BREEDING LINES FOR LIVESTOCK, ENERGY, AND INDUSTRIAL UTILIZATION
McBee GG, Dept. of Soil & Crop Science, Texas A & M University, *College Station, Texas, 77843*, (TEX06289)
OBJECTIVE: Determine genetic variability in major grain and forage sorghum breeding lines for cyanogenetic glucoside levels. Determine inherent variation in levels of certain carbohydrate fractions plus true and apparent digestibility of stover among selected grain and forage sorghum parental material. Evaluate stover for industrial and energy utilization.
APPROACH: Grow selected breeding lines under known population and fertility conditions. Flag leaf samples analyzed potentiometrically for p-HCN. Selected sections of plant analyzed for carbohydrates by hydrolysis and spectrophotometric technique and true and apparent digestibility by in vitro method. Energy and industrial determinations involve fermentation, mass spectrometry and calorimetric methods.
PROGRESS: Sorghum type plants rank as one of our most important forages, yet due to potential HCN (pHCN) poisoning of livestock, careful management must be exercised. Fifteen entries mostly from popular sorghum breeding lines were grown under nitrogen and maturity variables. Representatives were from Caffrourm, Feterita, Feterita-Candatum-Kaura, Caudatum-Kafir, Zerazera, Caudatum non-senescence, Milo, Zerazera non-senescence, Sudanease, Durra and Dochna. The youngest two leaves were analyzed for pHCN. Significant variation in pHCN among lines was obtained. Increases in pHCN was obtained with added N for lines inherently low in dhurrin. Significant decreases of pHCN were noted after plant inflorescenses were removed. Two publications on this are in progress. More efficient utilization of plant biomass for energy and other functions is becoming critical. Two contrasting types of sorghums, Rio and Combine Kafir 60, were grown under variable plant spacings and harvested at different dates on a selected diurnal cycle. Leaves were removed, culms sectioned, oven dried and processed for subsequent sugar analysis. More basic information of this type is needed for guidance on periods of harvest for maximum sugar concentrations.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0137
POLICY IMPLICATIONS OF PROVIDING FEDERAL SUBSIDY FOR HIGH VALUE ADDED CHEMICALS FROM BIOMASS
Neuworth M, Metrec Division, Mitre Corp., *McLean, Virginia, 22101*, (PRA80-23709)
OBJECTIVE: The National Energy Act "provides an exemption from the 4 cent Federal excise tax on gasoline for fuels containing a mixture of at least 10 percent alcohol, produced from agricultural products or waste." This policy provides a strong financial incentive to allocate significant biomass resources to the production of ethanol and methanol, and it is consistent with a current need in the U.S. to produce liquid fuels to displace imported petroleum. An alternative use of biomass resources is to produce other oxygenated chemicals that exhibit higher value added (HVA) than ethanol or methanol. Since these HVA chemicals are currently produced from petroleum feedstocks, their production from biomass resources would directly displace petroleum. This project proposes to determine economic,

technologic, and market implications of an extension of current Federal policy to subsidize production of HVA chemicals from biomass resources. Data will be developed for biomass resource availability and costs, conversion technology design, costs, and production characteristics, product production costs, markets for HVA chemicals, net energy balances, petroleum displacements, and Federal program costs. The proposed analysis will enhance the capability of existing models to address Federal policies for the allocation of extensive biomass resources and represent a contribution to the national goal of decreasing U.S. dependence on imported petroleum.
SUPPORTED BY: U.S. National Science Foundation.

4.0138
ALCOHOL FUEL TRAINING
Anderson RH, Undergraduate School, Southwest Wisconsin Vocational Technical Inst., *Fennimore, Wisconsin, 53809*
OBJECTIVE: The objectives are to promote liquid fuel energy independence for southwest Wisconsin, establish an alcohol fuel technician training program, and develop and conduct a comprehensive hands on learing situation for Wisconsin farmers which will address the needs of the energy farm scale alcohol fuel industry.
APPROACH: A small scale (less than 50,000gallons per year) alcohol fuel distillation unit utilizing available off the shelf hardware, local mechanical expertise, and facilities at a local vocational-technical institute will be constructed. The expected result is a trained cadre of alcohol fuel technicians capable of building and operating a still and safely using the alcohol fuel product.
SUPPORTED BY: U.S. Dept. of Energy.

4.0139
TECHNICAL AND ECONOMIC EVALUATION OF ON-FARM ALCOHOL PRODUCTION UNITS
Converse JC, Holmes BJ, Reed RH, Dept. of Agricultural Engineering, University of Wisconsin, *Madison, Wisconsin, 53706,* (WIS05157)
OBJECTIVE: To evaluate the performance of on-farm stills as to energy inputs and outputs and operational problems. To evaluate the economics of on-farm stills as to labor and other costs.
APPROACH: Each unit selected for study will be evaluated for type and quantity of energy input, type of feedstock used, quantity of alcohol output, quality and quantity of by-products including distillers, grains, and wastewaters. Investment costs, labor, and supply costs will be evaluated for costing out the alcohol on a per unit basis.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0140
CONVERSION OF ANIMAL WASTES TO METHANE GAS AND TO SINGLE CELL PROTEIN USING PHOTOSYNTHETIC BACTERIA
Ensign JC, Dept. of Bacteriology, University of Wisconsin, *Madison, Wisconsin, 53706,* (WIS02342)
OBJECTIVE: The purpose of this investigation is to develop procedures for recycling of farm wastes. The products to be produced are methane gas, microbial protein and fertilizer. Another goal is concomitant formation of a low nutrient, non-polluting effluent solution. The ultimate goal is operation of rurally located factories for waste recycling.
APPROACH: Anaerobic fermentation of cow and chicken manures at meso- and thermophilic temperatures produce methane gas and high levels of volatile fatty acids. Comparisons of various fermentation operations will be made to optimize formation of gas and fatty acids. A separation step removes insoluble materials which can be used as fertilizer or feed supplement. The supernatant fluid is used to grow photosynthetic bacteria which convert most of the organic matter into protein. A continuous flow system for efficient production of protein will be studied. The next phases of the investigation will involve scale up to pilot plant and, if economically feasible, to factory size operations.
PROGRESS: The purpose of this investigation is to efficiently convert animal wastes, particularly chicken manure, to energy as methane gas and to single cell protein. A 20,000gal. fermentor located on a farm at Ripon, Wisconsin has been in operation for several years. The methane generation capacity has been improved until 4,000cu. ft./day is now being produced. This amounts to a value of methane of only $4.05 per day. We are convinced that a major consideration for treating farm animal wastes by fermentation is to recover a protein-rich material to be recycled as animal feed. The particulate matter in the digestor effluent contains 20-25% by dry weight of protein. The liquid fraction is converted by use of photosynthetic bacteria into single cell protein. Over half of the initial weight of chicken manure can be converted to high quality single cell protein using the combined anaerobic digestion-photosynthetic bacteria treatments. Energy as methane gas is also produced and there are no potentially polluting effluent materials to deal with. Laboratory scale experiments indicate that the process is economically feasible.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0141
USE OF SPENT GRAIN RESIDUES FROM POWER ALCOHOL PRODUCTION IN RUMINANT RATIONS.
Satter LD, Dept. of Dairy Science, University of Wisconsin, *Madison, Wisconsin, 53706,* (WIS02683)
OBJECTIVE: To expand utilization in ruminant rations of by-product grains obtained in power and beverage alcohol production. To develop practical means of ensiling wet by-product grains to minimize energy cost of drying spent grains. To determine whether small amounts of starch and protein which are relatively resistant to microbial breakdown in the rumen can significantly enhance utilization of low quality crop residues such as corn stalks.
APPROACH: A lactation trial involving 150 Holstein cows in early lactation will be conducted to determine if a resistant protein source, such as spent grains, can stimulate milk production. Spent grains will be compared to soybean meal and heat treated soybean meal as protein supplements for lactating cows. Wet spent grains will be ensiled with corn husks and corn cobs in an effort to identify a practical means of handling wet grains and of utilizing corn crop refuse in dairy rations. Initially, ensiled wet grains-corn crop refuse will be fed to lactating cows in digestion studies. If ensiling works, and if acceptability of the material by cattle is good, then lactation studies will be planned. Resistant and easily degradable protein and starch sources will be tested for their ability to stimulate feed intake when cattle are fed low quality crop refuse diets.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0142
EVALUATION OF LOW-LIGNIN BIOMASS FOR FERMENTATION TO FUEL ETHANOL
Harkin JM, Dept. of Soil Science, University of Wisconsin, *Madison, Wisconsin, 53706,* (WIS02684)
OBJECTIVE: To determine the suitability of a variety of plant materials and farm residues of low lignin content as substrates for fermentation to ethanol under conditions which can be adapted for low technology processes suitable for use "on the side" on farms or in vegetable canneries.
APPROACH: Through cooperation with the Energy Committee of the Wisconsin Canners and Grocers Association, unit processes in the harvesting and processing of specialty vegetable crops will be studied and attractive solid and liquid wastes selected to test their potential for conversion to fuel ethanol. Comparisons will be made with current disposal methods, the crystallinity of the cellulose will be determined by X-ray diffraction, and the hydrolysis of the polysaccharide fraction of the fresh and stored wastes with acids and enzymes examined. In this way it will be determined which wastes hold promise as substrates for hydrolysis to simple sugars to provide a fermentation mash for fuel ethanol production.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

4.0143
STUDIES ON NUTRIENT ENRICHMENT OF ORGANIC FERTILIZERS FROM WASTES USING ISOTOPIC TECHNIQUES
Sachdev MS, Subbiah BV, Nuclear Research Lab, Indian Agricultural Research Inst., *New Delhi, India, New Delhi 110012,* (2722/RB)
OBJECTIVE: The investigations under the project aim at studying the optimal conditions for cross blending and enrichment of spent slurry obtained from cow-dung biogas plants with mineral fertilizers. The evaluation of methods of storage and application of slurry in relation to its fertilizer quality. Enrichment of slurry with nitrogen, phosphorus, and other nutrients and to study the fate and plant availability of these blended organic fertilizers in pot and microplot field experiments using isotopic techniques.
SUPPORTED BY: International Atomic Energy Agency.

4.0144
OPTIMIZATION OF ANIMAL WASTES TREATMENT WITH REFERENCE TO BIOTREATMENT, RECOVERY OF GAS, PROTEINS, AND AGRICULTURAL UTILIZATION OF EFFLUENTS
Oleszkiewicz JA, Wroclaw Division, Research Inst. on Environmental Development, *Wroclaw, Poland,* (L770D-F002)
OBJECTIVE: The project will attempt to optimize the existing treatment system for a large hog farm and evaluate the production of biogas, production of protein, and the production of yeast from the wastes. Also land application of the effluent will be evaluated for possible ground and surface water contamination. The project will produce a report detailing the processes investigated, their efficiencies and the economics of each system. The initial laboratory scale work is complete. Field modification of the test treatment plant is scheduled for late 1978.
SUPPORTED BY: U.S. Environmental Protection Agency, Office of Research & Development.

4.0145
ENERGY RECOVERY FROM STRAW THROUGH ITS USE AS FUEL
Jansson I, Dept. of Farm Buildings, Swedish University of Agricultural Sciences, *Lund, Sweden, S22006, Lund 6,* (780580-0)
OBJECTIVE: This project relates to the use of straw as fuel. After allowing for the amount of straw used in animal husbandry, there still remains an annual production of about 4.8 million tons of straw in Sweden, corresponding to a theoretical fuel value content of 24 TWh.
APPROACH: The work is based on an earlier system investigation, which was financed with funds from BFR, and involves the following elements: 1. Economic costing of different methods of straw collection and of firing. 2. Determination of the availability of straw, based upon available statistical material. 3. Methods of collection; field studies. 4. Methods of drying and storage; field studies. 5. Follow-up of current development work relating to straw firing and to suitable boilers. 6. Heat storage, calculations and experimental work. 7. Determination of heat requirements for different types and sizes of farms. 8. Testing of the system in actual operation.
SUPPORTED BY: Statens Rad for Byggnadsforskning.

4.0146
USE OF REED AND STRAW IN SMALL CONVENTIONAL BOILERS
Schuster R, Fjarrvarme AB, *Trosa, Sweden, S15013 Trosa,* (53 1360 412)
OBJECTIVE: To determine the special considerations needed when using straw in small boilers for solid fuel. The study intends to give manufacturers and users of solid fuel combustion units knowledge how straw can be used as fuel in an efficient way.
APPROACH: Compilation of existing data concerning straw as fuel. Compilation and evaluation of results from existing units. Identification of the need for research and development.
SUPPORTED BY: Namnden for Energiproduktionforskning.

4.0147
CALCULATION OF STRAW PRODUCTION IN SWEDEN, THE EFFECT OF INPUT COMBINATION, AND THE INFLUENCE ON BALANCE OF SOIL ORGANIC MATTER
Pettersson I, Dept. of Ecology & Environmental Res., Swedish University of Agricultural Sciences, *Uppsala, Sweden S75590 Uppsala*
OBJECTIVE: To determine the potential of crop residues for future energy production. The result will be of interest to government authorities. It will provide background for future investments in agriculture as source of raw material for energy production. Hopefully the result also will interest some farmers to make their own experiments. This aspect should not be neglected, since some suggestions already are profitable.
APPROACH: To calculate yearly production of crop residues for different regions and different crops, with special attention to cereals. To investigate different possibilities for increasing the production of crop residues by means of careful selection of input combination, increased acreage of cereals and crop rotation. To investigate possible effects on soil organic matter, starting with a literature study. To make preliminary calculations in economic terms and of net energy relations in order to predict future alternatives of use.
SUPPORTED BY: Namnden for Energiproduktionforskning.

4.0148
METHANE PRODUCTION FROM MANURE
Noren O, Jordbrukstekniska Instituetet, Ultuna, *Uppsala, Sweden, S75007 Uppsala 7*, (79-5200)
OBJECTIVE: To investigate the effects of various factors on the formation of methane gas from manure and other agricultural waste. To study and make recommendations for potential uses of methane gas, to evaluate the effectiveness of the digested media, to study odor reduction in connection with digestion, and to draw up security regulations for methane gas installations.
APPROACH: The laboratory tests will comprise the development of methods of analysis to be used for evaluation of the methane fermentation process, including determination of limit values and a description of the fermentation process in terms of chemistry. Full-scale tests will be carried out involving direct comparison of how various factors affect gas formation, etc. Studies will be conducted concerning different mixing techniques, different retention times, mesophilic and thermophilic digestion, gas production using various agricultural waste, heat exchange, and various methods of starting up the digestion process. Accurate energy balances will be made and various uses for the digested gas, for instance for heating purposes and in power production, will be investigated. The fertilizer value will be studied by means of parcel methods and the possibility of reducing smell by determination of odor thresholds will be investigated.
SUPPORTED BY: Styrelsen for Teknisk Utveckling.

5. ENERGY FROM FOREST PRODUCTS AND RESIDUES

5.0001
GAS SORPTION BY SOILS
Bohn HL, Dept. of Soils, Water & Engineering, University of Arizona, *Tucson, Arizona, 85721*, (ARZT-170663-51-14)
OBJECTIVE: Measure the soil sorption parameters of organic and inorganic gases to measure the decomposition rates of such gases in soils.
APPROACH: The sorption of hydrocarbon and organic gases by soils will be measured by an adaptation of gas chromatography. The gas retention by the soil column will be related to soil properties such as surface area, clay content, and organic matter content. In batch studies, relevant organic compounds will be added to soils and after known time periods will be eluted from the soil. The release and sorption of N(2)O by soils will be measured in closed chambers before and after wetting the soil. N(2)O is measurable at low concentrations by gas chromatography.
PROGRESS: The natural sorption of gases by soils is a major determinant of the nitrogen, carbon, and sulfur composition of the atmosphere. The N(2)O concentration of the atmosphere is affected by N(2)O release by acid soils particularly. A gas chromatograph with a tritium electron capture detector has been modified to analyze ambient N(2)O concentrations. Experiments are beginning to determine if alkaline (pH greater than 7) soils, when moist, are capable of adsorbing appreciable N(2)O from the atmosphere. The ability of soils to adsorb air pollutants is being tested on the flue gases from residential coal and wood burning. These gases contain particulates, polyaromatic hydrocarbons, sulfur and nitrogen oxides, and carbon monoxide. All of these except CO are adsorbed, or rapidly reacted upon, by soils. Carbon monoxide reactions are much slower. The experimental apparatus to test the effectiveness of soil treatment of residential flue gases is almost complete. The removal of polyaromatic hydrocarbons, sulfurous and nitrogenous gases and dust by soils from the waste gases of wood and coal combustion will be measured.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0002
THE USE OF UNDERSTORY VEGETATION AS A RENEWABLE BIOMASS ENERGY RESOURCE.
Ku TT, Baker JB, Williams RA, Dept. of Forestry, University of Arkansas, *Monticello, Arkansas, 71655*, (ARK1002)
OBJECTIVE: Determine nature, character and extent of understory vegetation within uneven-aged pine and pine-hardwood southern forests as a renewable biomass energy resource. Determine attitude of non-industrial landowners toward public harvest of understory. Determine recovery rate of resource after harvest. Determine long term effects of periodic harvests of understory biomass and site quality.
APPROACH: A factorial experiment with two forest types, two site classes, two density classes, and five replications will be used to establish 40 main plots in the South Arkansas and North Louisiana area. Main plots will be approximately 0.5 acres in size. Three 10'x 10' paired sub-plots will be established with all understory vegetation below 5.6" dbh to be harvested by clipping from one plot of each pair in summer and the second plot to be harvested in winter. Subsamples from the green chips will be ovendried and used to determine baseline data for quantifying long term effects of periodic harvest on site quality. Landowners will be canvassed to assess availability of understory biomass for energy.
PROGRESS: This cooperative project between UAM, USFS, and Georgia-Pacific Corporation will evaluate the potential use of understory vegetation as a renewable energy resource in uneven-aged pine and pine-hardwood stands in South Arkansas and North Louisiana. Objectives include: (1) characterization of understory vegetation to determine number and size by species, biomass dry weight and nutrient content; (2) determine resource recovery rate after harvest; and (3) determine long-term effects of periodic biomass harvests on site quality. Use of understory biomass could supplement energy supplies, increase growth of overstory crop trees, and eliminate the need for brush control, thereby reducing site preparation costs. Forty 0.2 ha. main plots from a factorial design with 5 replications of 2 forest types (pine and pine-hardwood), 2 density classes (high and low), and 2 sites classes (high and low) will be established in an 11-county area. All woody vegetation less than 14 cm. dbh will be inventoried from 18 subplots. Nine subplots are to be harvested in summer and 9 in winter, with soil samples to be collected immediately after harvest. Nutrient content of biomass and soil samples will be determined to evaluate effect of nutrient drain on site quality.
SUPPORTED BY: Arkansas State Government.

5.0003
GROWTH/YIELD AND ENERGY POTENTIAL OF NATURALLY OCCURING BOTTOMLAND STANDS OF SOUTHERN HARDWOODS
Fountain MS, Undergraduate School, University of Arkansas, *Monticello, Arkansas, 71655*, (ARK00949)
OBJECTIVE: Determine the total aboveground biomass of selected commercial and non-commercial hardwood species and the percentage of the total aboveground biomass contained in the various tree components. Develop prediction equations for green and dry weight of total trees and tree components and volumes of each species, develop polymorphic site index curves from stem analysis data for various commercial hardwood species, and develop growth/yield tables for unmanaged bottomland hardwood stands.
APPROACH: Field collection of data will be accomplished in two phases. Data for the development of weight tables for the various species will be obtained by destructive sampling of trees from diameter classes representative of the range for each species. Growth/yield information will be obtained from 1/5-acre plots located so as to sample stands representative of the various age class-site type combinations found in this region.
PROGRESS: The initial objective of completing a species composition study of proposed sites has been accomplished. This information was needed to ensure that only species or species groups that are important species with regard to density, dominance, and frequency are sampled in the destructive sampling phase of the project (biomass determination). Study sites for the yield plots have also been located in the majority of the major and minor bottoms that will be included in the study. Sampling of these plots will begin during Summer, 1980.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0004
PYROLYSIS-GASIFICATION OF ORGANIC RESIDUES — FOREST AGRICULTURE — FOR ENERGY AND PRODUCT RECOVERY
Brink DL, Dept. of Forestry & Conservation, University of California, *Berkeley, California, 94720*, (CA-F#-FPL-2905-H)
OBJECTIVE: Develop data for design of processes involving production of energy, isolation of fuel gasses and/or organic chemicals, and/or inorganic chemicals of value from biomass residual generated in forestry and agricultural enterprises.
APPROACH: Bench-scale reactor will be redesigned and operated specifically to provide indirect heat by incorporating down- or cross-draft gasifier with shaft or rotary-type gasifier to maximize production of energy, organic products of value, and/or synthetic gas.
PROGRESS: Continued study of the Pyrolysis-Gasification-Combustion (PGC) process for converting biomass materials or their derivatives to chemicals and/or energy includes completing and submitting the final report to EPA demonstrating technical feasibility of the PGC process applied to kraft black liquor (KBL). The PGC experimental unit and its operation at 2.0 metric tons (MT)/day of 45% solids KBL were described in detail. Especially significant results are: continuous conversion of KBL solids to only smelt and PG gas, smelt comprises Na(2)S — reduction to sulfide is over 90%, PG gas contains only H(2), CO, CO(2), H(2)0, CH(4), N(2), Ar, and H(2)S — no malodorous, sulfur-containing organic compounds are present. Methods used to predict scale-up of operations to a 91 MT/day commercial module and a 1365 MT/-day recovery plant have been published. It is predicted on a commercial scale: less than 10% of the total sulfur of KBL will be converted to H(2)S. On scrubbing, H(2)S can be virtually eliminated, H(2)S not removed will be converted to SD(2) on combustion of PG gas and SO(2) can be controlled within a prescribed limit, scrubbing will remove dust by nucleation as the PG gas is collected below its dew point, thus eliminating electrostatic precipitators, smelt-type furnace explosions will be prevented by elimination of steam generation and water cooling of walls and floor. KBL used to scrub H(2)S from PG gas.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0005
OXIDATIVE UTILIZATION OF WOOD AND OTHER LIGNOCELLULOSIC MATERIALS
Brink DL, Dept. of Forestry & Conservation, University of California, *Berkeley, California, 94720,* (CA-F#-FPL-2905-H)
OBJECTIVE: Based upon oxidative reactions develop technically and economically feasible/and environmentally compatible processes utilizing wood and other lignocellulosic materials.
APPROACH: Using oxidizing agents modify the lignocellulosic moiety in wood and residuals of forestry and agriculture to produce products of commercial value.
PROGRESS: Oxidative hydrolysis-wet combustion-fermentation was designed as an environmentally benign process to produce ethyl alcohol (for fuel), methane, process energy requirements, and optionally, acetic and other organic acids. Delignification: oxidative pretreatment of pulp chips using oxides of nitrogen includes two systems: gaseous nitric oxide oxygen (NO) and aqueous nitric acid (NAL). Followed by soda pulping as a second stage (NALS) pulps produced had properties approaching those of NOS kraft pulps. Characterization of NOS black liquor has included organic acids and precipitable lignin. Lignocellulose modification: A. Bonding (interproject with 2904 and 2926) by NAL pretreatment of wood flakes followed by application of a crosslinking agent, gave particleboards with superior overall properties in the 0.45-0.75 density range compared to those obtained using hydrogen peroxide in the pretreatment stage. B. Of pretreatments studies, NO was most efficient for improving enzymatic hydrolysis of cellulose to glucose (cooperative study with Mr. Ron Borrevik and Prof. C. W. Wilke, Chem. Eng. Dept.). Structural analysis of lignin: two papers were presented at the May, 1978, meeting of TAPPI-ACS.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0006
MARKETS AND MARKETING OPPORTUNITIES AS APPLIED TO COLORADO FOREST PRODUCTS
Betters DR, Dept. of Forest & Wood Sciences, Colorado State University, *Fort Collins, Colorado, 80523,* (COL00071)
BJECTIVE: Identify alternative utilization and marketing strategies that are technically and economically feasible for near-total consumption of wood raw materials generated by mountain pine beetle control programs, evaluate the relative economic merit of alternatives, and recommend procedures needed to implement the most favorable strategies. Determine the market areas, volume, and value for existing products, and other possible new products now currently being produced in Colorado and evaluate production and marketing alternatives that can be supported by various levels of forest management.
APPROACH: The methodology will consist of several segments or phases, identify potential market areas, identify characteristics of the market areas relating to consumption of forest products, develop and test alternative production and marketing strategies based on raw material available, product potentials and market demand and relate the suggested strategies to forest management programs for Colorado.
PROGRESS: Emphasis for research needs will be in the area of domestic fuelwood energy alternatives in the State of Colorado. These include firewood, pelletized fuelwood, biomass conversion, and mill and logging residues as domestic fuelwood. A further breakdown of research needs in these areas include markets, supply, economic efficiency, energy efficiency, and environmental and other non-market considerations. Since the research needs in the wood energy field are quite extensive, a methodology is now being developed to prioritize these needs so that an effective study plan can be designed. The general format of the study plan involves the identification of fuelwood energy alternatives, examples of existing alternatives, circumstances making these alternatives viable and areas in Colorado where similar circumstances exist.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0007
AIR POLLUTION EMISSION INVENTORY OF FIREPLACES
Buchan R, Dept. of Microbiology, Colorado State University, *Fort Collins, Colorado, 80523,* (COLV 05514)
OBJECTIVE: Provide accurate information on the impact of fireplaces as an air pollution source in Vail, Colorado so that sound decisions can be made with respect to emission control strategies.
APPROACH: This initial phase of the project will be for the purpose of gaining background information, refining experimental design, developing a data tabulation format, and developing a data analysis model. Second phase of the project will be devoted to data collection. The time period of this phase was selected as it is the peak ski season and fireplace usage should be at its highest. Final phase of the project will be for data analysis, evaluation, conclusions and preparation of a report with recommendations. Data collected will be analyzed in accordance with established statistical methods and evaluated accordingly.
SUPPORTED BY: U.S. Dept. of Agriculture.

5.0008
WOOD REMOVAL IMPACT ON SMALL, PRIVATE, NONINDUSTRIAL FOREST
Bethune JE, Dept. of Natural Resources Conservation, University of Connecticut, *Storrs, Connecticut, 06268,* (CONS00525)
OBJECTIVE: Relate Connecticut private, nonindustrial forest conditions including the present heavy fuelwood and sawtimber removals to present and future environmental quality and wood supply.
APPROACH: Determine current supply-removal forest dynamics from consecutive aerial photos with ground checks. Relate current timber removals to environmental changes, specifically soil, water, and aesthetic. Project future forest and related environmental conditions.
PROGRESS: A study of forest products, supply, availability, and drain from private ownerships in Northeastern Connecticut is in progress. The study shows that the majority of forests in the area are at the transition stage between poletimber and sawtimber. Also about 12% of the forest land was cut over between 1965-1975 and about 10% between 1975-1979.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0009
UTILIZATION OF SOUTHERN TIMBER
Saucier JR, Southeastern Forest Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Athens, Georgia, 30601,* (SE-3101)
OBJECTIVE: Characterize the southern timber resource and develop the technology to improve utilization processes, product yields, reduce waste, and conserve energy.
APPROACH: Research studies will be conducted to determine the total-tree biomass of southern softwood and hardwood species, so we can determine how much additional fiber is obtained when tops, branches, root systems, understory trees, and cull trees are harvested. Physical and chemical properties of wood and bark will be examined to determine their influence on product utilization. Trees and logs will be followed through primary processing, when possible, to determine ways of improving lumber, veneer, pulp, and fuelwood yields.
PROGRESS: Increasing fossil fuel cost has stimulated interest in alternate fuels including wood. There is a strong demand and apparent need for methods of estimating volume, weight, and Btu value of that portion of our renewable resources that have previously been under-utilized or wasted. Studies have been completed that present prediction equations and yield tables of volume and green and dry weight of the complete tree and by its components (wood and bark by merchantable stem limits, total stem and crown). The species for which we have these data are: loblolly, shortleaf, slash, longleaf and sand pines and yellow-poplar, northern red oak, southern red oak, scarlet oak, sweetgum, white oak, and chestnut oak. Prediction equations have also been developed for understory trees below 5-inches d.b.h. that previously were considered unmerchantable. These include: Yellow-poplar, red maple, sweetgum, dogwood, hickory, blackgum, post oak, white oak, southern red oak, chestnut oak, and sourwood. In the Appalachian Region, there are limited markets for low-quality hardwoods. A study has demonstrated the feasibility of using bolter saws to produce short-length lumber suitable for furniture manufacture. An analysis of research priorities for eastern hardwoods has been made to help guide future research of this valuable resource.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0010
STATE DEMONSTRATION PROGRAM IN WOOD ENERGY
Bistany E, Engineering Experiment Station Georgia Inst. of Technology, *Atlanta, Georgia, 30332,* (A-2400)
OBJECTIVE: This project is the second year of a multi-year project directed to accelerating the commercialization of wood energy for non-forest products industries. The project is a joint effort by the Georgia Office of Energy Resources and the Georgia Tech Engineering Experiment Station. Georgia Tech manages the project, contracting through the Georgia Tech Research Institute. The primary objective of this project is to encourage the replacement of oil and gas with wood fuel.
APPROACH: Key program elements designed to remove the barriers to rapid commercialization are: (1) development of a Wood Energy Extension Service to provide widespread technical assistance to industry; (2) continued supervision of the three demonstration projects begun under Phase I; (3) in-depth analysis of specific problems in supply, storage, and drying of wood fuels delineated in Phase I as well as better definition of fuel property standards; (4) survey of potential wood gasification applications in Georgia and practical test programs on gasifier operational problems; and (5) technology transfer through seminars, publications, tours of demonstration sites, and presentations at national conferences.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

5.0011
MODEL FOR INSTALLATION BIOMASS MANAGEMENT (DA0H8097)
Severinghaus WD, Baran RS, Construction Engineering Research Lab., U.S. Dept. of Defense, Army Corps of Engineers, *Champaign, Illinois 61820,* (DAOG5871)
OBJECTIVE: To develop guidelines for the analysis of the environmental feasibility and monitor the long term effects of utilizing forest products and/or by-products as an alternate energy source on US army installations. The product of the effort will be a system to provide this information on a short term level for installations and to initiate a long term monitoring program for various management practices (FY84).
APPROACH: Examine soil nutrient loss due to sustained forest harvesting practices. Analyze and adapt existing mensuration techniques and programs for army applicability. Examine environmental effects for various types of forests, forest uses, and energy plantations. Develop and field test biomass environmental feasibility system (BEFS). Monitor long term effects of biomass program for various management practices.
SUPPORTED BY: U.S. Dept. of Defense, Army, Corps of Engineers.

5.0012
FURNACES UTILIZING SAWDUST
Bodganowics Z, Performing Institution Not Reported.
OBJECTIVE: Numerous experiments have been conducted to eliminate the binding agent for pressing sawdust. To achieve this, it was necessary to increase the pressure in the pressing process to 15,000lbs/sq. inch and increase the temperature of the forms to approximately 500 degrees F. The drying process for sawdust was eliminated because under high pressure the juices in the wood particles serve as binding agents on sawdust particles, and the high temperature of the forms

creates an additional layer of dry tree sap on the surface of the pressed planks and logs, which increases its mechanical strength. To facilitate the loading of the furnace with loose sawdust, a simple, practical and clean method of loading the furnace with sawdust was installed using special cartridges. These are five-inch thick planks of pressed sawdust, the shape and size of the furnace, with holes as openings for air supply tubes. Depending on the need, the furnace could be loaded fully or partially thus making energy conservation through the use of waste by-products even more affordable and efficient.
SUPPORTED BY: U.S. Dept. of Energy.

5.0013
VOLUME TABLE AND PRODUCTION TIME FOR HARDWOOD FIREWOOD
Mize CW, Dept. of Forestry, Iowa State University, *Ames, Iowa, 50010,* (IOW02293)
OBJECTIVE: Develop a composite firewood volume table for oak and hickory and determine the time and cost required to perform various phases of firewood production.
APPROACH: Cut a sample of trees of various sizes into firewood and measure the volume produced. Adapt an old table from Pennsylvania or develop a new one. Do a time motion study of firewood production and determine various costs.
PROGRESS: Twenty-five red oak and white oak trees with diameters from 10 cm to 45 cm have been examined. On each tree, measurements were taken on crown size, height, and diameter. Each tree was converted to split firewood and measured. From the data, a whole tree fuelwood volume table and a top wood fuelwood volume table have been prepared. (Whole tree volume (cords) equal to 0.0044 plus 0.00003258 multiplied by D 2H RSQ equal to 0.97 and topwood volume (cords) equal to minus 0.0061 plus 0.00002304 multiplied by D 2H RSQ equal to 0.89 with D equal to DBH (cm) and H equal to total height (m)). It is intended to use this information in large fuelwood production program being developed at Iowa State.
SUPPORTED BY: Iowa State Government.

5.0014
EVALUATION OF WOODLAND MANAGEMENT OPPORTUNITIES IN IOWA
Wray PH, Iowa Agricultural & Home Economics Experiment Station, Iowa State University, *Ames, Iowa, 50010,* (IOW02172)
OBJECTIVE: Determine the effects of past and present management practices on private woodlots and the existing forest cover. Develop better guidelines and management tools for management of Iowa forest resources for fiber production. Evaluation of alternative uses for forested land such as pasture, recreational developments, cropland, and urban development. Reevaluate the effect of tree barriers on wind movement.
APPROACH: Develop better yield and growth information for selected hardwoods. Study response of selected species to cultural treatments. Study and monitor regeneration techniques, as to type of natural regeneration that occurs with respect to species, density, and time. Study in select counties the history of past forest and non-forest use and analyze the influence of past practices on present conditions.
PROGRESS: Because of increased interest in use of wood as a home heating fuel and the potential impact of this use of existing woodlots in Iowa, a study of the economics of firewood production compared to other land uses has been started. Preliminary results indicate this use of woodlands can compete favorably with many other uses including land clearing and converting to annual crops.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0015
AN EVALUATION OF THE ECONOMIC IMPACT OF FIREWOOD PRODUCTION AND UTILIZATION IN KANSAS
Warner TD, Dept. of Forestry, Kansas State University, *Manhattan, Kansas, 66502,* (KAN00128)
OBJECTIVE: Determine the economic impact of firewood production and utilization in Kansas through determination of recent trends (5 yrs.) in firewood production and reidentification of the existing marketing structure for firewood in Kansas; determination of estimated future demand for residential firewood in Kansas; determination of the firewood supply base needs to meet estimated future residential demand.
APPROACH: Identify and collect sales data from firewood distributors in the state, identify and collect supply data from firewood producers, identify and collect information on sales of wood-burning stoves, chain saws, and the installation of fireplaces in new homes, Develop a predictive model to estimate future firewood demand.
PROGRESS: Since this project was approved in late November, 1979, work has centered on finalizing study sampling procedures. This work includes: determining the "Market Cities" to be targeted for the survey; determining contact procedures for fuelwood marketers; woodburning stove and chainsaw distributors, housing contractors; and development of survey instruments for the collection of data. The initial survey work will take place in March, 1980.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0016
CONDUCTING A DEMONSTRATION AS TO THE PRACTICALITY OF AN ENERGY FOREST AS A FUEL RESOURCE FOR THE UNIVERSITY
Geyer WA, Dept. of Horticulture & Forestry, Kansas State University, *Manhattan, Kansas, 66502,* (KAN-05-496)
OBJECTIVE: Determine the optimum sources of wood fuel to meet the energy demands of the University of Kansas steam generating plant.
APPROACH: Establish rapid fiber test plantations at representative sites in the Lawrence area for biological and energy yield, plus economic analysis. Evaluate various forms of wood fuel for availability, handling, processing, and storage. Conduct an urban "waste" wood and sawmill residue survey.
PROGRESS: In April an additional site was added to the study at Lawrence. It is a sandy loam area on the Kansas River floodplain. Four, 1/5th acre "wheel" spacing plots were established. One species planted to a "wheel": cottonwood, black locust, silver maple and Siberan elm. About 8 acres of land at Sunflower (loamy upland area) were planted with silver maple, catalpa, and Siberian elm using the best spacing, herbicides, and equipment available to start an "energy forest." Casoron, a post planting herbicide, at an 8 lbs/A rate in 4-ft. wide strips successfully controlled weedy competition without any apparent damage to the planted seedlings. The weeds between the 9-ft. rows were mowed frequently. European black alder was eliminated from all future consideration in a planting program because it survived poorly in the summer dry spell and suffered greatly in the harsh winter a year ago. First year growth results for all sites was as follows: cottonwood 5 ft. black locust 3 ft. Siberian elm 2 1/2 ft. soft maple 2 ft. and black alder 1 ft. After two seasons cottonwood and black locust appear to be the better species based upon a calculated (non-destructive sampling) Btu yield. About a 25-50% difference exists between these two species and the other three. Time and motion studies were conducted for the large area planting and after 3 growing seasons cost efficiency between species and spacings will be determined.
SUPPORTED BY: Kansas State Government.

5.0017
ECONOMIC STRUCTURE AND PERFORMANCE OF THE KENTUCKY SAWMILL INDUSTRY
Graves DH, Redman JC, Agricultural Experiment Station, University of Kentucky, *Lexington, Kentucky, 40506,* (KY00606)
OBJECTIVE: Determine present and emerging economic structure of Kentucky's sawmill industry. Simulate an industry system for evaluating potential levels of economic efficiency. Identify and evaluate potential changes in lumber processing and distribution and in technologies employed leading to lower cost through improved levels of marketing and development. Identify long run economic structural changes and adjustments resulting from adoption of cost-reducing technologies.
APPROACH: Economic structure of the Kentucky sawmill industry will be determined in order to evaluate recent changes due to economic pressures. New technologies will be determined and utilized in the development of a minimum economic size of production. This, correlated with basic raw material supplies and operational factors, will be used to determine optimal distribution of firm size for selected lumber producing regions in Kentucky.
PROGRESS: During the life of this project a study was conducted to construct a programming model that would adequately portray the alternative production and marketing strategies encountered by today's sawmill entrepreneur. This model was developed and tested and could prove to be a valuable tool if utilized by the industry. Another model was developed to depict the status-quo of a sawmill during any particular production run and to display the alternatives available to him to increase profitability. This model is presently being utilized by the Kentucky Division of Forestry as an analysis tool on Kentucky sawmills. Other valuable results of this project have been the development of research efforts into the utilization of sawmill wastes for mulches and fuel sources. Such research has already eliminated economic waste of this material at many sawmills and is now being utilized. This project has also led to an ongoing study that is investigating the alternative merchandising of materials removed prior to surface mining to make them more usable to the sawmill industry in the respective areas.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0018
PROCESSING SOUTHERN WOODS
Koch P, Southern Forest Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Alexandria, Louisiana, 71360,* (SO-3201)
OBJECTIVE: Provide fundamental knowledge and practical information leading to new and improved conversion processes and systems for the complete utilization of southern tree species.
APPROACH: Characterization analyses of selected tree species will provide the basic information to develop processes and products from tree portions not suited to solid wood products. New processing or machining equipment will be designed to reduce solid wood portions into the best sizes and shapes for manufacturing secondary products. Low-cost, non-petroleum-based adhesive systems will be developed with curing and bonding characteristics suited to producing reconstituted wood and fiber structural and panel products.
PROGRESS: To provide information needed to more completely utilize southern trees, data were published on the anatomy of bark of 11 southern oaks, the specific gravity of wood and bark of above-ground tree parts of 22 species of 6-inch hardwood trees growing on southern pine sites, and tool forces when orthogonally cutting them. To further the utilization of small trees of all species, extensive information on the manufacture of structural flakeboards and composite boards was published; an illustrated review of present and potential processes to convert wood to energy was printed. Field tests of a swathe-felling mobile chipper; a shaping-lathe headrig, and a green fuel burner progressed sufficiently to indicate ultimate practicality and industrial usefulness. An integrated process for virtually complete utilization of hardwoods on southern pine sites was conceived. To utilize most of the high-yield biomass of southern pine trees, new processes were invented. A concept for high-yield mechanical pulping was patented, as was a process for producing cellulose ether derivatives (Durso, D.F. Serial No. 24551). Distribution of the Proceedings of the RWU's Symposium, "Complete-tree Utilization of the Production on Chipping Headrigs" was published. The RWU continued strong support of the information retrieval system (AIDS) of the Forest Products Research Society; the usefulness of AIDS is greatly enhanced by its new availability on-line from SCS--a major computer service.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0019
MARKETING AND UTILIZATION OF MAINE FOREST PRODUCTS AND ECONOMICS OF INTENSIVE MANAGEMENT OF MAINE FORESTS
Field DB, School of Forest Resources, University of Maine, *Orono, Maine, 04473*, (ME42802)
OBJECTIVE: Provide information which will enhance the ability of Cooperative Forestry Research Unit sponsors to grow timber extract (and possibly process) that timber, and merchandise the resulting products in such a way as to maximize the long-run return (monetary or otherwise) on the fixed elements of the investments involved, subject to socio-economic and biophysical realities.
APPROACH: Compile resume of relevant research completed or ongoing within the school, the sponsor group, other academic institutions, the state, and the federal government. Meet with and tour the lands of the major sponsors. Develop a 5-year program analysis for sponsor review, followed by detailed project proposals. Begin specific project program research.
PROGRESS: Three formal sub-projects continue: utilizing spruce budworm-damaged timber; potentials for a Maine hardwood charcoal industry; public benefits from private forest land ownership and management in Maine. A survey of Maine's mill operators found little experience with milling dead timber. Enough live timber has been available for operators to avoid using budworm-damaged material. Our problem analysis consists mostly of a literature review of problems encountered in harvesting and milling dead and damaged timber elsewhere in the U.S. Charcoal research continues, with a new interest in charcoal fuel for gasogen motor vehicle engines. A report entitled "The Economic Importance of Maine's Spruce/Fir Resource" is nearing completion. It examines present and expected future supplies and utilization of spruce/fir timber reported by 16 of Maine's largest forest landowners, and includes forecasts of potential demands for spruce/fir timber to the year 2020.
SUPPORTED BY: Maine State Government.

5.0020
WOOD RESIDUES AS FUEL STOCK FOR WOOD GAS GENERATORS
Rice WW, Agricultural Experiment Station, University of Massachusetts, *Amherst, Massachusetts, 01102*, (MAS00026)
OBJECTIVE: Characterize residues available for fuel in terms of quantity, source, variability, form, bulk density, moisture, and Btu content. Develop cost-performance data. Develop material specifications.
APPROACH: Research is divided into discrete units based on source and differences in factors affecting efficiency of use of residues -forest residues, mill residues, urban waste.
PROGRESS: This project has been reduced in scope to a demonstration unit. Review of proposed fuel feeding system with industrial personnel (Energex Co.) revealed better methods and technology already exists in the field. Continuation with the proposed system would develop no new knowledge. The gasification unit used to produce wood gas for gas chromatograph analysis by one graduate student is an independent study project. White Pine Chips burned at 7-8%M.C. produced no visible particulate in the stack. The gas temperature prior to combustion was about 1100 degrees C. The gas analysis was not complete due to equipment problems. The furnace-gasification unit will continue to be demonstrated as appropriate using hand and semi-automatic feed units.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0021
DEVELOPMENT OF WOOD-ENERGY PROJECT
Gregory GR, Dept. of Fisheries, Forestry & Wildlife, University of Michigan, *Ann Arbor, Michigan*, (MICY00116-F)
OBJECTIVE: Develop a multidisciplinary research program to investigate the ecological, economic, political, and social implications of using wood as a basis for producing electricity in Michigan.
APPROACH: State and federal agencies, forest industry, university faculty, and the public will be asked to help determine significant questions that should be addressed. Individual study proposals will then be developed, coordinated, and submitted to interested agencies for funding.
PROGRESS: Increasing demand (and cost) for firewood, a Forest Service study of the Northern Lake States considering 100/ energy self-sufficiency in the forest products industry, a 1977 Michigan Governors Conference on Wood Energy, and a proposal for a 25 MW electrical generation plant in Hersey, Michigan have combined to cause concern for the proper utilization of Michigan's forest resources. The School of Natural Resources Wood Energy Project was initiated in response to interest from public agencies, private concerns, and citizens groups for development of a multidisciplinary research program to investigate the ecological, economic, political, and social practicality of using wood as a basis for energy production in Michigan. With funding from The University Office of Energy Research, a literature review and in-depth evaluation of the problem was conducted. It was concluded that present energy problems and related economic change, government policy, and citizen reactions could cause significant increase in the fuel utilization of Michigan's forest resources. A proposal prospectus was developed and submitted to the Department of Energy (DOE) and Department of Agriculture, Forest Service in November to determine their interest in funding a study. The project awaits a response from DOE.
SUPPORTED BY: Michigan State Government.

5.0022
NUTRIENT UTILIZATION IN INTENSIVELY CULTURED FOREST CROPS
Boyle JR, Dept. of Forest Resources, University of Michigan, *Ann Arbor, Michigan, 48104*, (MICY00070-F)
OBJECTIVE: Evaluate nutrient requirements of intensively cultured forest crops. Evaluate capacities of soils to supply these nutrients.
APPROACH: Review the literature and file data on nutrient uptake of intensively cultured forest crops and related information on soil supplies of nutrients and ecosystem nutrient dynamics. Analyze data on soil properties and plant nutrient contents for whole-tree chipping operations. Calculate preliminary nutrient budgets and define additional needed research.
PROGRESS: In cooperation with the Forest Management Division of the Michigan Department of Natural Resources and the staff of the Huron-Manistee National Forest, U.S.F.S. we completed an evaluation of Michigan forest soils for potential impacts of intensive harvesting of wood for energy. We suggest a 3-category grouping of 63 soil series in the study area. Based on pH and texture of both surface and deep horizons, soils are classified as (1) least likely to exhibit impacts, (2) intermediate, and (3) most likely to exhibit impacts. These classifications are the result of detailed nutrient budget 'evaluations of a few intensively-studied soils and extrapolations to other series based on comparisons of characteristics of soils and forest types. Our proposed system can be a useful contribution to management planning with inputs to the system being available information on soils and forest stands.
SUPPORTED BY: Michigan State Government.

5.0023
ENERGY CONSUMPTION IN THE AMERICAN HOUSEHOLD: 1900 TO 1977
Morrison BM, Dept. of Human Environment & Design, Michigan State University, *East Lansing, Michigan, 48823*, (MICH-1375)
OBJECTIVE: This research is designed to understand from a broad national, as well as historical perspective, household energy consumption in the United States. The general objectives are to describe the patterns of household energy consumption (via percentages and British Thermal Units) for 7 major energy sources, 1900-1977, to describe how the demand for household energy has changed for the 7 major energy sources, 1900-1977, to describe what social, economic, political, and technical influences have helped shape both the patterns and the demand for household energy consumption, 1900-1977.
APPROACH: The approach used for the analysis of statistical data which includes national level household energy consumption (2 coal sources, 2 sources of natural gas, electricity, fuel oil and wood), as well as national level demographic, expenditure,and housing data for 1900-1977 is to perform a descriptive analysis to discern patterns of household energy use for 7 energy sources. Comparable national patterns will be evaluated.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0024
ENGINEERING SYSTEMS AND MECHANIZATIONS FOR NORTHERN FOREST STANDS
Arola RA, U.S. Dept. of Agriculture North Central Forest Expt. Station, Michigan Technological University, *Houghton, Michigan, 49931*, (NC-3701)
OBJECTIVE: Develop engineered systems and equipment which are needed to economically meet forestry objectives in northern forest stands.
APPROACH: Research will concentrate on harvesting and transportation of the residues left in the forest. Residue recovery will be approached as a material handling and processing problem in both mature and immature forests. New equipment and systems will be developed to economically convert low-valued, residue-type materials such as small trees, tops, limbs, stumps, and roots into a form suitable for handling, transporting, and product development. Research will also include the problems of production of energy from forest resources, with particular emphasis on forest residues and mortality stands. Approaches will include recovery of residues for energy uses, methods and equipment to convert rough residues into suitable fuel products as well as achieving quality control of residues by developing concepts for ridding such fuels of moisture and contaminants (dirt and grit).
PROGRESS: A method for calculating equipment costs which is being recommended as a standard has been developed for loggers to better appraise the efficiency and production costs of their equipment and for those involved in teaching in universities or training centers as a teaching aid. Preliminary trials of sorting high valued sawlogs from whole-trees before chipping indicated a significant economic potential. Further multi-product studies will emphasize refining the mechanics of a woods landing sorting operation to maximize production efficiency and recovery of resources for their highest valued end use. Increased utilization of the available forest resource mandates the development of systems and techniques capable of segregating the various parts of the whole-tree into their highest value and product. Besides providing chips for fiber or fuel from the residue portions of the trees, such systems will also expand the available supply of high quality sawlogs. A technique for sorting wood and bark chips on the basis of their light transmittance has been developed. Preliminary trials have shown that 70 to 80 percent of the wood fiber can be recovered with less than a 2 percent bark content.--A 13 acre field trial of a strip selection method for thinning northern hardwood pole sized stands yielded 78 tons of whole-tree chips per acre at a production costs of $8.64 per green ton.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0025
ECONOMIC ANALYSIS OF THE CHANGING DEMAND FOR TIMBER IN THE LAKE STATES
Kallio E, Dept. of Agriculture North Central Forest Expt. Station, University of Minnesota, *Duluth, Minnesota, 55812*, (NC-4203)
OBJECTIVE: Determine and measure effects on the future demand for timber in the Lake States. Determine the economic limitations of using forest residues as an energy source for the pulp and paper industry. Determine the economic consequences of full tree removal in the aspen-birch type. Determine barriers affecting the more efficient use of softwood lumber for structural use in residential housing.
APPROACH: Wherever possible, information will be collected on wood product demand from secondary sources. Information on full tree removal and availability of forest residues for fuel will be collected from existing forest survey plot data. residue measurement, and harvest and transport cost estimation. Simulation and access models will be used to analyze the data. Information collected from lumber truss fabricators and other

sources will be used in determining barriers affecting the more efficient use of softwood lumber.
PROGRESS: Declining supplies of veneer quality timber will increase prices to home builders and others requiring structural grade sheathing. Production of a structural flakeboard for use as a plywood substitute was shown to have a competitive advantage in midwest markets when produced from surplus volumes of aspen in northern Minnesota. Recent application of improved computer simulation languages has shown that harvest models can predict real system output within 10 percent. Using these models to test many different combinations of equipment and operating procedures, loggers can plan more efficient operations to help save high machinery and energy costs. To keep pace with new products and processes, business management needs reliable information about current and future forest product markets. A source book has been developed to provide wood industry managers, service and research organizations, and consumers with a fast, effective reference source for forest product market and business information. County lands are managed uniquely in contrast to others in Minnesota because they depend on revenues generated from within land departments to cover to expenses of administration each year. Information developed on the trends in county land ownership, administration, and timber harvest can assist other public owners and private forest product manufacturers develop long-range timber management and procurement.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0026
THE DEVELOPMENT OF NEW AND IMPROVED WOOD PRODUCTS AND MANUFACTURING PROCESSES
Bowyer JL, Petersen H, Ketter K, Dept. of Forest Products, University of Minnesota, *St. Paul, Minnesota, 55108,* (MIN-43-004)
OBJECTIVE: Analyze and develop means of overcoming technical problems in the manufacture of lumber, dimension, plywood, particleboard, and various other products from the abundant but typically small-size and low grade species of Minnesota. Tn the immediate future, objectives will be to: investigate potential systems for effecting separation of saw-quality bolts from material which is typically harvested to obtain pulpwood only, investigate the technology and economics of a new product, face glued stripboard, from small diameter and low grade hardwood species and demonstrate use of queueing theory in the design of small-log sawmills to optimize design of plant infeed in in-process conveying systems. The purpose is to improve economics of small log recovery systems.
APPROACH: Work on harvesting systems will involve application of previously developed computer simulation models to logging processes to evaluate effects of system changes. Laboratory manufacture and testing of stripboard products will be primary method of evaluating technical feasibility of this product. An economic analysis will follow.
PROGRESS: The second phase of the investigation of potential for solid wood core, veneer-faced, and faceglued only wood panels was completed. High grade structural panels from low grade hardwoods were found technically and economically feasible, and capital requirements for establishment of a commercial manufacturing plant were determined to be quite low. A project to investigate the effect of core strip length on bending properties of panels was initiated. Results of the study involving adaptation of queueing theory to design of processing facilities were published. One-step cost minimization solutions were shown to be obtainable using the technique. Development of a case study of model application is near completion. A project has begun to evaluate the economics of sawlog recovery by concentration site merchandising of material traditionally used as pulpwood. Considerable data was collected during numerous visits to log concentration sites across Northern Minnesota. Research to investigate utilization of disease killed elm was continued, with efforts directed at both industrial/commercial and residential wood heating. Information was gathered from managers of four governmental operations and three business organizations involved in energy production from elm. A hand-held mechanized debarker was also field tested.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0027
USE OF ECONOMICS IN PLANNING PUBLIC FORESTRY PROJECTS AND INVESTMENT BUDGETS
Gregersen HM, School of Forestry, University of Minnesota, *St. Paul, Minnesota, 55108,* (MIN-42-049)
OBJECTIVE: Assess existing guides to economic analysis of forestry projects in terms of applicability to specific types of projects and agency situations. Assess constraints on more widespread application of economics in project planning and budgeting. Develop means for overcoming constraints and develop specific guidelines for use of economics in forestry project planning by state and federal agencies.
APPROACH: Interviews and literature will establish present planning procedures and use of economics by public forestry agencies. A comparison will be made of existing procedures with those suggested in literature. Desirability of, and means for introducing new approaches will be analyzed. Potential impacts associated with introducing expanded use of economics in forestry project planning and budgeting will be analyzed. Guides for use by specific agencies will be developed and tested and the implications of such guides in terms of public objectives and agency practices will be assessed.
PROGRESS: Major results of the project were completed and published. A survey of watershed projects in Minnesota and the use of economic analysis in preparing such projects was completed. There are few forestry related watershed projects in Minnesota that have involved major economic considerations. Watershed activities in the State tend to be in response to regulations and involve in some cases simple cost-effectiveness criteria. Exploratory work was initiated on firewood economics, using projections of wood cost and availability in relation to alternative heating fuel costs in Minnesota. A number of draft manuscripts on various aspects of project analysis are being completed for publication.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0028
WINDBREAK, SHELTERBELT, AND SMALL WOODLAND STUDIES
Scholten H, School of Forestry, University of Minnesota, *St. Paul, Minnesota, 55108,* (MIN-42-072)
OBJECTIVE: Find new tree and shrub species for use in farmstead shelterbelts and field windbreaks, including use under center pivot irrigation systems. For each tree species recommended for field windbreaks, determine the spacing and management practices which will prevent soil erosion and give uniform snow distribution. Improve design and management practices of farmstead shelterbelts to prevent snow damage to young trees; and maintain vigorous trees and maximum protection throughout the life of the belt. Produce containerized conifers to improve survival and growth when planted in windbreaks and shelterbelts. Improve maintenance of windbreaks and shelterbelts through herbicide treatments. Improve management practices in small private woodlands.
APPROACH: In cooperation with the SCS, plant various shrub and tree species of known seed sources in test plots on Experiment Station land and cooperative private farms to screen for use in windbreaks and shelterbelts. Various spacings and design will be used in new windbreak and shelterbelt plantings on Experiment Station land and cooperative private farms to determine optimum spacing and design. Young plantings will be maintained, in part, by various herbicied treatments and methods of application. Containerized conifers will be tested on Experiment Station land and on cooperative private farms. In co-operation with DNR and SCS, recent interest in fuelwood as an energy source will be used as an incentive to improve management practices in small private woodlands.
PROGRESS: Planting bare-root conifers in shelterbelts is discouraging to farmers because it may take 3-4 years for significant height growth while roots are becoming established. Container-grown stock should eliminate this problem because roots are not disturbed–the problem is to determine the most efficient and economical size container. A 1976-77 study revealed that 41 3m containers were too small. In January 1979, using 30-compartment styrofoam block containers, 4 conifer species (Siberian larch, Douglas fir, Norway spruce, ponderosa pine) were used in seeding 100 containers. The media was a commercial peat-vermiculite mixture.
SUPPORTED BY: Minnesota State Government.

5.0029
IDENTIFICATION AND DEVELOPMENT OF HIGHEST VALUE USES FOR THE TOTAL TREE BIOMASS
Sinclair SA, School of Forestry, University of Minnesota, *St. Paul, Minnesota, 55108,* (MIN-43-066)
OBJECTIVE: Determine total volume and weight of wood harvested by species and final use category; then of the total biomass harvested, the proportion used for sawlogs, wood fiber, energy and miscellaneous products will be determined along with the amount left in the woods and the amount of bark. Analyze the economic feasibility of utilizing presently unused biomass.
APPROACH: Data describing the total harvested volume of forest biomass by species, final use category, and geographic location will be compiled. Following the basic data analysis, target species and industries will be selected on the basis of the relative amounts and concentrations of unused biomass, and alternative methods of utilizing the unused resource will then be studied.
PROGRESS: Since work began on this project in April of 1979, two main topics have been investigated. The first topic concerned an estimation of the amounts, types and locations of secondary and primary mill residues in the State of Minnesota. The second topic investigated has been a review of the present literature concerning estimation and utilization methodology of wood residues. Our efforts in determining the amount of mill residue in the State of Minnesota have been successful. By contacting 132 major wood using firms within the State of Minnesota we have determined type and location of 700,000[2] green tons of mill residue produced during 1979. Fifty-nine percent of these residues are contained within the northern pine forest survey unit in Minnesota and the majority of these residues are hardwood bark and coarse chippable hardwood residues. Our literature review of wood residue estimation and utilization methodology and also a review of present institutions, agencies or corporations in Minnesota utilizing wood residues for energy is completed. We expect this work to be published in the near future. Other work this year has involved the beginning of an insect-damaged balsam fir utilization and marketing project and also additional work on insect-damaged softwood sawtimber of other species.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0030
ECONOMIC OPPORTUNITIES AND CONSTRAINTS TO IMPROVING PRODUCTIVITY ON PRIVATE NONINDUSTRIAL FORESTS
Moak JE, School of Forest Resources, Mississippi State University, *Mississippi State, Mississippi, 39762,* (MIS-0689)
OBJECTIVE: 1) Identify constraints which limit adequate provision for regeneration on pine sites after harvest on private nonindustrial forest lands; 2) develop recommendation to remove constraints in item 1) above; 3) develop an energy wood supply curve on private nonindustrial forest ownerships.
APPROACH: Sixty sample properties within each of four counties will be randomly drawn within size of ownership strata from the population of owners who have harvested timber within the past five years. The land will be inspected for proper regeneration, personal characteristics of the owners, and their management strategy for the land. Thirty sample properties within each of 4 counties will be randomly and proportionally drawn within size of ownership strata. A field inventory, to include currently non-mechantable wood, will be made of each property and each owner interviewed to determine his asking price for

this timber by classification. From this a landowner energy wood supply curve will be developed.
PROGRESS: A stratified random sample of 60 ownerships was drawn from the population of ownerships where pine harvesting has occurred during the last five years. This was from one Central Mississippi county. (Additional counties will be included as the study is expanded). Each property owner was personally interviewed and his property inspected to determine its condition after harvesting. The ownerships were then divided into two groups; those who did reforest and those who did not. Analyses will be made to determine if identifiable characteristics can be used to predict a landowners propensity to reforest after harvesting. Analyses will also be made to search for constraints to reforesting that show promise of removal by available means.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0031
KILN-DRYING PROPERTIES, HEARTWOOD COLOR FORMATION AND CHARCOALING CHARACTERISTICS OF NATIVE WOODS
McGinnes EA, Brown MC, Cutter BE, School of Forestry, Fisheries & Wildlife, University of Missouri, *Columbia, Missouri, 65201,* (MO00174)
OBJECTIVE: Kiln-drying studies of native species (emphasis on drying properties of various abnormal wood formations); discoloration (in service) and/or due to injury and development of normal heartwood coloration for selected native species, and shrinkage and micropore formation resulting from transformation of wood into charcoal under varying conditions of batch kiln operations in Missouri-type charcoal kilns.
APPROACH: Sample material will be obtained either from trees exhibiting results of environmental mishap or treatment or else from specific industry where a particular problem exists. Existing techniques, or modifications thereof, will be utilized wherever possible. SEM, X-ray, and image processing procedures will be utilized to describe ultrastructural change in transformation of wood into charcoal.
PROGRESS: Information on ash content and cell-wall porosity of selected wood species upon charring have been obtained under a wide range of temperature conditions. Four publications and a thesis have resulted from this work. This information is important in the understanding of what happens when wood is transformed into charcoal. Additional studies along the same lines are planned. Data on the relationship(s) between anatomical structure, soil conditions, rate of growth, and genetic influence on color properties of black walnut veneer are being studied. One publication (abstract) has been released. One thesis is nearing completion. Color is considered an important factor in determining the price of fine hardwood veneers.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0032
THERMOCHEMICAL CONVERSION OF BIOMASS TO SYNTHETIC GASEOUS FUELS USING A LARGER EXPERIMENTAL FACILITY
Flanigan VJ, Dept. of Engineering Management, University of Missouri, *Rolla, Missouri, 65401,* (AC02-79ET23029)
OBJECTIVE: The University of Missouri-Rolla Wood Gasification GROW Project is a development program in wood gasification funded by the Department of Energy. The purpose of the program is to determine scale-up factors for low, medium, and high Btu gasification processes for transition from mid-scale to commercial size operations.
APPROACH: The program is a phased program and the phases relate to the Btu content of gas produced including the final phase of a specific industries utilization task. The Coors resource recovery system donated to the University of Missouri-Rolla by the Adolph Coors company has been modified and is being used to obtain the necessary development data. The modifications include the insertion of a sleeve and many other changes. The development task program focuses on the operation of a fluidized bed reactor designed to handle mass flow rates of 200 to 2000 lbs/hr with and without a catalyst to determine design and operating parameters for wood residue gasification using this type of reactor. At the conclusion of the development, it is expected that reliable scale-up data for design and operating conditions will have been established. The development program will also provide information on the economics of operating such systems, the market potential for the products, and the data base needed for technology transfer and commercialization of this process.
PROGRESS: The project is presently engaged in converting the plant from Phase I low Btu gas to Phase II medium Btu gas. The experimental portion of Phase I is 98% complete with only several runs being needed to totally complete the phase. The scale factors and economics are being prepared for reporting. The first test of the system in the Phase II configuration is planned for mid-August and the modifications are on schedule for this start-up date.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

5.0033
PYROLYTIC CONVERSION OF LIGNOCELLULOSIC MATERIALS
Shafizadeh F, Dept. of Chemistry, University of Montana, *Missoula, Montana, 59801,* (PFR-78-18096)
OBJECTIVE: The impending shortage of chemicals and other materials and the limited supply of petroleum necessitate new efforts for efficient utilization of renewable lignocellulosic materials. Pyrolysis, the controlled thermal treatment of materials, provides an efficient process for converting lignocellulose into a wide range of useful products including sugars, chemicals, solvents, charcoal and fuel. The overall objective of this project is to examine promising routes for converting lignocellulosic materials to useful chemicals through pyrolytic means. Specific objectives are to: 1. investigate the thermal depolymerization of cellulose in wood and agricultural materials into levoglucosan (an anhydride of glucose); 2. examine in an integrated fashion, the pyrolytic processes for producing furfural, acetic acid, methanol and carbon as byproducts from the hemicellulose and xylan components of the raw materials; 3. establish the application and utility of the novel pyrolytic products, especially levoglucosan and levoglucosenone; 4. investigate the use of thermal treatments to increase the susceptibility of cellulose to enzyme hydrolysis.
SUPPORTED BY: U.S. National Science Foundation.

5.0034
CHEMICAL UTILIZATION OF CELLULOSIC MATERIALS
Shafizadeh F, Dept. of Chemistry, University of Montana, *Missoula, Montana, 59801,* (PFR-80-23854)
OBJECTIVE: The impending shortage of chemicals and other materials and the limited supply of petroleum necessitates new efforts for the efficient utilization of renewable lignocellulosic materials. Pyrolysis, the controlled thermal treatment of materials, provided a means for converting lignocellulose into a wide range of useful products including sugars, chemicals, solvents, and charcoal. The overall objective of this project is to examine promising routes for converting lignocellulosic materials to useful chemicals through pyrolytic means. Specific objectives are to investigate (a) the thermal depolymerization of cellulose in softwoods to a mixture of fermentable sugars and charcoal and (b) the potential applications of novel pyrolytic products such as levoglucosenone (a reactive, cyclic derivative of glucose) as chemical intermediates.
SUPPORTED BY: U.S. National Science Foundation.

5.0035
IMPROVING WOOD RESOURCE HARVESTING AND UTILIZATION
Barger RL, Intermountain Forest & Range Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Missoula, Montana, 59801,* (INT-3251)
OBJECTIVE: Facilitate the harvesting and utilization of underused timber resources in the Rocky Mountains, including small timber, dead and cull trees, mixed material from salvage operations, and residues from harvested areas.
APPROACH: The research program will direct the modification of existing harvesting and utilization technology and practices, and the development and evaluation of new concepts, to accomplishing improvement in utilization of the total available wood resource. Recovery of low-value and residue material for energy uses, and for utilization in the manufacture of conventional wood products, will be the focus of the research. Specific areas of investigation will include: Development and evaluation of harvesting technology that can facilitate economic removal of small or low-value timber; development of efficient handling, sorting, and pre-processing methods for utilization of small or low-value material; identification of technically and economically feasible product, process, and market opportunities; and identification of the role and environmental implications of timber harvesting as a multi-resource land management tool.
PROGRESS: Research has been directed toward developing, testing, and demonstrating systems and practices for improving the recovery and use of forest residues in an environmentally acceptable manner. Harvesting system research has included testing and evaluating existing conventional systems, as well as developing and testing new concepts and methods. Product and process research has demonstrated the feasibility of utilizing small stems, dead timber, and other residues for a wide array of conventional products. Extensive evaluations of the physical and biological consequences of timber harvesting have defined the influence of alternative utilization levels and practices upon the forest ecosystem. The results provide a basis for developing timber harvesting prescriptions to reduce environmental impacts and enhance management of multiple forest resources. Related engineering research is investigating the influence of alternative forest road design and construction practices on soil and water resources.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0036
IMPACT OF THE CHANGES IN MARKETING CHANNELS ON THE NEW HAMPSHIRE AGRICULTURAL SECTOR
Andrews RA, Frick GE, Inst. of Natural & Environmental Resources, University of New Hampshire, *Durham, New Hampshire, 03824,* (NH00220)
OBJECTIVE: Describe service areas of farm supply marketing firms; describe service areas of farm product marketing firms; relate farm firms to input and product marketing firms, develop flows of farm products through market channels and evaluate assembly and distribution functions; enumerate marketing practices that influence market availability; evaluate adequacy of markets and market channels for meeting current and prospective needs.
APPROACH: Information on farm supply firms and product marketing firms and the necessary data relating farms to these firms will be developed from state records, other secondary sources, and from survey methods. Flows through marketing channels will be developed and routing systems evaluated by available computer programs. Marketing practices will be determined and assessed on economic efficiency criteria including alternative marketing systems.
PROGRESS: Cash registers were placed in five different roadside markets during the two summers of 1977 and 1978. Generalized sales patterns were developed. The seasonal sales pattern for individual markets is made up of weekly cycles. The weekly sales pattern remains consistent throughout the season regardless of the type and quality of produce available. During the week, sales are highest in the afternoon; during the weekends, sales are highest in the morning. Average sale per customer for all markets was $2.20 in 1977 and $2.80 in 1978. The cost structure of fuel wood production and marketing firms was studied using a budgetary-type, input-output approach. Costs were found to be influenced greatly by type of yarding machine, differing combinations of equipment to complete the cutting, splitting, loading, and delivery of fuel wood. Farm tractors

were lowest cost only at low production levels, crawler tractors were more efficient at relatively short skidding distances, and skidders were more efficient at the longer skidding distances. Delivery costs were found to depend on size of delivery and distance. Substantial economies of scale were experienced in the production system up to a production level of 2,000 to 2,4000 cords output per year with current technology.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0037
TIMBER VALUES AND HARVESTING COSTS IN CENTRAL NEW HAMPSHIRE
Foster BB, Barrett JP, Inst. of Natural & Environmental Resources, University of New Hampshire, *Durham, New Hampshire, 03824,* (NH00014-M)
OBJECTIVE: Develop general guideline for cost estimations of various logging methods, including emphasis on fuel requirements. Develop instructions for applying the 3-P technique to New England commercial timber species. Develop computer-oriented decision-making models using the above information.
APPROACH: Make time studies of logging operations using various logging methods under various stand, weather and topographic conditions. Special attention is given to fuel requirements (hay and grain in addition to petroleum products). Make laboratory and field applications of Grosenbaugh's 3-P technique of volume and value determinations. Follow selected, measured trees through the milling process to determine accuracy of the predicting regressions. Review existing computerized decision-making models, converting the more applicable into actual computer-programmed tools which would be perfected for use by decision-making field foresters. Make field studies (case studies) in order to compare the usefulness of the resulting tools when used in conjunction with information generated in 1 and 2 above.
PROGRESS: Residual stands from firewood removals classified by information on the Intent to Cut tax forms as improvement cuts or harvest cuts were essentially alike in species composition, trees per acre, and basal area. While the residual mean basal area on those classified as improvement cuts was larger than on the harvest plots, the variability was so great as to preclude concluding a real difference.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0038
IMPROVED UTILIZATION OF WOOD (LIGNOCELLULOSE) THROUGH MICROBIAL GENETICS
Eveleigh DE, Montenecourt BS, Agricultural Experiment Station, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJO1300)
OBJECTIVE: Increase the potential of wood as a renewable base for the production of fuels and petrochemical substitutes through construction of a series of hyper-lignocellulolytic, catabolite repression resistant and end product inhibition resistant mutants of white rot fungi.
APPROACH: A series of selective plate screening assays will be developed to screen for hyperenzyme secreting mutants of white rot fungi for the enzymes involved in cellulose and lignin degradation. Mutant organisms will be characterized with emphasis on the role of cellobiose; quinone oxidoreductase as the key enzyme in the cometabolism of lignin and cellulose. Genetic crosses will be made utilizing the sexual stage of the fungus to improve strains and determine genetic linkages. Somatic cell hybrids will be obtained by protoplast fusion of white rot mutants as well as Trichoderma reesei mutants in a continuing effort to select superior lignocellulolytic strains.
PROGRESS: The utilization of lignocellulose by the white rot fungus Phanerochaete chrysosporium was studied with emphasis on a unique enzyme cellobiose: quinone oxidoreductase (CBQOR) which is thought to be a link between cellulose degradation and lignin degradation. A petri plate screening procedure for CBQOR was devised using dichlorophenol indophenol (0.35 mg/ml) and cellobiose (0.35 mg/ml) in 0.2 M acetate buffer at pH 5.5 as a colorimetric indicator system. The enzyme is produced maximally late in submerged culture fermentations (14 days). Purification of the enzyme has been achieved by sequential ion exchange chromatography and isoelectricfocusing. The purified enzyme shows maximal activity toward cellobiose, with reduced activity towards higher cellulose. The selection of mutants strains of P. chrysosporium is ongoing.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Reserach Office.

5.0039
ECONOMIC CHARACTERISTICS OF FUELWOOD HARVESTING IN NEW MEXICO
Gray JR, Agricultural Experiment Station, New Mexico State University, *Las Cruces, New Mexico, 88003,* (NM00020MS)
OBJECTIVE: Determine fuelwood supplies, present and predicted, by species, by key and harvested supply areas of New Mexico. Measure investments and costs of fuelwood harvesting by both dealers and consumers harvesting their own wood. Ascertain the socio-economic characteristics of fuelwood users and construct fuel energy budgets indicating net gains or losses in harvesting fuelwoods in various areas.
APPROACH: Data from Federal Forest Service and State Forestry dealing with fuelwood supplies and harvests will be tabulated and related to fuelwood management policies. Historical trends in fuelwood production and use will be determined from published data, and projected to 2000. Individuals issued cutting permits will be tabulated, a sample drawn and a mail questionnaire sent to the selected samples. Personal interviews will be made of chainsaw dealers. The mail questionnaire will deal with investments, costs, and fuel uses as well as socio-economic characteristics and characteristics of wood burning units. Analyses will include statistical projections of supply and demand, and cost and energy budgets.
PROGRESS: Free-use fuelwood harvesters on national forest areas of New Mexico harvested an average of 17.32 m 3 of wood (4.78 cords) in the 1977-78 season, of which 40% was pinyon, 26 percent was ponderosa pine and 20% juniper. They averaged using 11.09 1 of gasoline per m 3 (10.6 gal. per cord). They invested $607 per party in harvest vehicles and equipment. They had doubled the amounts harvested per party from 1972-73 to 1977-78 and estimated a 26% increase by 1980-81 with increased energy prices and reduced fuelwood supplies. Approximately 66% of the homes of harvesters used fuelwood for heating and the remainder for cooking and a combination of cooking and heating. Based on inventories, annual use and annual increments of dead and down fuelwood, some national forests in New Mexico will exhaust inventories in as few as 9 years. Others have sufficient inventories and annual increments to provide wood from inventories for up to 46 years. Statewide, inventories will last until the 1998-99 season. For each unit of energy used to harvest wood, only 1.01 units of heat were received when wood was burned in fireplaces and 3.98 units when wood was burned in stoves. Oak consistently yielded more net energy.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0040
PRODUCER GAS AS A PETROLEUM SUBSTITUTE
Gunkel WW, Albright LD, Reines R, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123423)
OBJECTIVE: Critically examine the known technology of making producer gas. Determine the feasibility of using this technology to reduce the dependence of agriculture in the Northeast on conventional fuel sources. Design, construct and test a producer gas system including: Gas generator, filter, heat exchanger, fine filter and engine. Prepare a summary report of the study including an economic analysis of producer gas substitution for conventional fossil fuels and electricity.
APPROACH: The first phase of this study will be to determine an optimum size of the producer gas generator. Then a gas generator will be designed, constructed and tested. After completing the tests, the generator will be connected to a filtering and heat exchanger system and finally to an internal combustion engine. Operational characteristics of the system will be measured and any particular problems identified and corrected.
PROGRESS: A complete producer gas-internal combustion spark ignition engine system was constructed, instrumented, and tested. The gasifier unit was designed so that it could be easily changed from an updraft to a downdraft mode. Both charcoal and wood chips were used as fuel. The 4-cylinder engine was attached to a dynamometer to measure power output. Fuel burn rate, gas quality, air and gas flows as well as system temperatures were measured and recorded. Prediction equations for reaction completeness, gas calorific value and burner net efficiencies were developed for both charcoal and wood chips. Correlation coefficients of prediction equations to experimental data varied from a 0.94 to 0.951 for wood chips and from 0.986 to 0.997 for charcoal. Using data developed in the present study, a completely automated gas producer system using a microprocessor control system will be developed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0041
WOOD HEATING OF GREENHOUSES AND OTHER COMMERCIAL STRUCTURES
Stipanuk DM, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123430)
OBJECTIVE: Develop saw system for converting scrap wooden pallets to marketable wood. Identify potential greenhouse and commercial markets for scrap pallet wood. Identify additional sources of wood scrap. Identify existing furnaces and boilers suitable for handling wood scrap on a large scale.
APPROACH: A significant source of scrap wood and pallets has been identified and Cornell is working with this firm (LSW Industries). A large greenhouse grower in the area has expressed interest in the wood scrap for boiler fuel. These two parties will serve as the primary targets of the research. Information and experience from this undertaking will be used to encourage similar activities at other locations.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0042
USE OF FORESTS FOR FOOD AND FIBER
Morrow RR, Dept. of Natural Resources, Cornell University, *Ithaca, New York, 14850,* (NYC-147412)
OBJECTIVE: Develop biological and value growth data from thinning typical forest stands in New York. Develop long-term (15 years) sap flow and temperature data for two widely different geographical areas, and complete applied research on preheaters. Complete and publish long-term studies.
APPROACH: Remeasure trees by standardized procedures for growth. Analyze stand growth data. Review wood characteristics and fuel literature; apply to New York forest conditions. Keep yearly standardized records of sap flow, weather, and energy use at research stations. Seek relationships and publish results.
PROGRESS: Information on potential losses associated with harvesting forest biomass was collected from numerous visits to field stations in Eastern U.S. and from literature reviews. Forest production can be doubled, with much of the biomass used for energy. Increased productivity should come primarily from thinning crowded stands. To extract larger amounts of biomass, as suggested by Soc. of Amer. Foresters Task Force and others, risks increasing losses in soil productivity (loss of nutrients, OM, structure, soil erosion), valuable growing stock (indiscriminant cutting), water quality and aesthetic and wildlife values. Height growth is related to both site potential and capacity for branch extension. Thus, it is biologically related to spacing and thinning response. Spacing-height ratios are especially useful for intolerant conifers. Red pine, for example, grows well where average spacing is between 20 and 25% of dominant height. A commercial modification (Vapormid, designed to enhance formation of hydroxyle to act as a catalyst for burning fuel oil) was attached to an oil burner on a maple sap evaporator. Differences in evaporation efficiency were non-significant. Baffles placed in ar-

ches have provided little increased efficiency, but need more testing.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0043
DENSIFICATION OF WOOD FOR FUEL
Levi MP, School of Forest Resources, North Carolina State University, *Raleigh, North Carolina, 27607,* (NC04068)
OBJECTIVE: Determine the effects of various hardwood furnishes and processing parameters on the properties of densified wood to be used as a fuel.
APPROACH: Wood and bark from various hardwood timber species common in the Southeastern United States will be densified using pelletizing and other processing equipment. The effects of timber species, percentage bark, moisture content, and particle size on the quality of the fuel will be determined. Pellet friability, storability, and combustion characteristics are the properties which will be monitored. The use of additives (binders) and chemical modification of furnish will be studied if satisfactory pellets cannot be produced using steam and pressure.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0044
RATE OF FUNGAL DETERIORATION OF SOUTHERN PINE BEETLE-KILLED TREES AND ITS IMPACT ON UTILIZATION
Levi MP, Cowling EB, Holley DL, Dept. of Plant Pathology, University of North Carolina, *Raleigh, North Carolina, 27600,* (NC05329)
OBJECTIVE: Obtain information on rate of fungal deterioration of Pinus taeda killed by Dendroctonus frontalis Zimm. Develop simple field method of determining the length of time a beetle-killed tree has been dead. Develop economically sound management recommendations concerning utilization of the timber.
APPROACH: Determine the rate of fungal deterioration of beetle-killed standing, felled unsprayed, and felled lindane sprayed trees in the Mountain, Piedmont and Coastal regions of North Carolina, by measuring changes in moisture content, specific gravity, fungal species, chemical composition, and resistance to a pulsed electric current. Study changes in external characteristics of trees to develop a simple field guide for estimating time from death. Make management recommendations on the utilization of beetle-killed Southern pine based on information developed in this project, existing knowledge, and an analysis of the economic factors influencing salvage and utilization.
PROGRESS: Analysis of standing beetle-killed trees showed that rate of deterioration varied with area of the State. Utilization recommendations have been developed on the basis of the appearance of beetle-killed trees. This avoids the need for different recommendations for various areas. Also, such recommendations are more easily applied in the field where time of beetle-kill is often available. Beetle-killed trees have been divided into two broad appearance classes. Utilization recommendations for each of these classes based on the physical and chemical properties of the beetle-killed wood are: Class A - Beetle-killed; some needles to no needles, but most twigs. Can utilize lumber (with kiln drying), posts, panelling, plywood, particleboard, hardboard, pulp. Cannot utilize poles, piling. Class B - Beetle-killed; no needles some twigs to no needles no twigs, branches and tops broken. Can utilize decorative panelling, particle-board, hardboard, unbleached pulp, fuel wood. Cannot utilize lumber, posts, plywood poles, piling. The maximum time after death for which trees are usable ranges from approximately 2 years in the Coastal region to 4 years in the Mountains. This project has indicated that beetle-killed Southern pine is usable for a wider range of products and for a longer period than previously thought possible.
SUPPORTED BY: North Carolina State Government.

5.0045
CONVERSION OF FOREST RESIDUES TO A METHANE-RICH GAS
Feldmann H, Battelle Memorial Inst., Columbus Laboratories, *Columbus, Ohio, 43201,* (AT06-77RL99102)
OBJECTIVE: The objective of this program is to improve the technology and economics of gasifying forest residues and other biomass materials by the use of direct gasification catalysts and the application of a unique gasification reactor system.
APPROACH: The objective will be accomplished by the development of a multi-solid fluidized-bed reactor that allows the production of an intermediate-Btu gas or a synthesis gas without the use of oxygen and which requires minimal front-end preparation or drying of the biomass feed. The technical and economic feasibility of the process is being demonstrated in the program through the operation of a pilot plant with a nominal throughput of 200 lb/hr of wood feed. Successful outcome of the pilot plant work is expected to lead to a rapid commercialization of the process for utilization of biomass wastes, such as forest residues, agricultural wastes and municipal sludge for the manufacture of a medium-Btu gas for fuel or synthesis gas for methanol production.
SUPPORTED BY: U.S. Dept. of Energy, Div. of Solar Technology.

5.0046
HARVESTING SMALL LOGS AND RESIDUE WITH SKYLINES
Aulerich DE, Kellogg LD, School of Forestry, Oregon State University, *Corvallis, Oregon, 97331,* (ORE-FE-053-S)
OBJECTIVE: Test prebunching as a means of increasing the efficiency of thinning. Test downhill yarding over intermediate supports. Determine costs of yarding residue with large and small yarders. Compare costs of hauling chipped and unchipped residue. Determine falling, bucking, and yarding of hardwoods for energy production.
APPROACH: Conduct production analyses of harvesting systems during operations. Develop relationships to predict costs and production. Develop a simulation to estimate costs and benefits of harvesting and handling forest residues for energy production.
PROGRESS: Three studies were completed during 1978: hardwood and brush removal with a small skyline yarder; prebunching with a small yarder and swinging with a larger yarder; yarding downhill in a thinning with the small yarder. Mechanical removal of hardwood logs and brush with a cable machine does not seem to be a viable alternative to herbicides for improving young stands. Costs were prohibitive at $1127/acre. The field work for the prebunching study has been completed. Four skylines were prebunched (logs pulled laterally and piled in the skyline corridor) with the trailer alp yarder for swinging with a West Coast tower. Nine hundred prebunching turns and three hundred fifty swing turns were measured and recorded. Two skyline roads were lateral yarded with the West Coast only for a comparison with the two machine system. Three hundred twenty one turns were recorded. The downhill yarding study utilizes a system new to the United States. Production rates and costs will be evaluated over a range of conditions. Yarding tree-length pieces will be compared to yarding logs. The system utilizes the Trailer Alp Yarder with intermediate supports.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0047
SEPARATION OF NON-COMBUSTIBLES FROM WOOD AND BARK FUELS
Currier RE, Dept. of Forest Products, Oregon State University, *Corvallis, Oregon, 97331,* (ORE-FP-110-U)
OBJECTIVE: To gather information on the problem of separating rock, metal or other non-combustible materials from wood and bark residues to be utilized for fuel. To prepare a report for publication by the Forest Products Journal, or by the Forest Research Laboratory, depending on the urgency of the situation.
APPROACH: Conduct a search of the literature to yield knowledge on presently-used equipment and its location. Conduct personal visits and interviews at plants in the Corvallis vicinity. Contact known manufacturers of separation equipment to ascertain what new equipment they have planned. Also contact U.S. Forest Service engineers and manufacturers of "logging" equipment to help pinpoint problems that may occur when forest biomass becomes widespread as a fuel. Investigate the possibilities of a duel operation. Prepare a report for publication.
SUPPORTED BY: Oregon State Government.

5.0048
FOREST RESIDUES RD&A PROGRAM
Clarke EH, Pacific Northwest Forest & Range Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Portland, Oregon, 97208,* (PNW-2107)
OBJECTIVE: Direct a major RD&A Program effort towards developing practical and environmentally acceptable solution to the critical forest residues problems in the Pacific Coast States.
APPROACH: Aim efforts at developing guidelines for improved residue management planning capabilities. This will involve finding methods of predicting amounts of slash created by an activity and developing guides for specifying desired levels of residues; determining both long-term and transitory environmental effects of residues and an array of treatments, including prescribed underburning in partial-cut stands on steep slopes, exploring means of reducing residues through timber sale arrangements and harvesting techniques. Finally, refine and adapt decision frameworks for determining the "best" treatment from among alternatives. Strong emphasis will be given to transferring new technology to user groups.
PROGRESS: Techniques for effectively treating residues in partial-cut stands in the Douglas-fir subregion with prescribed burning have been developed and tested. A concentrated extension effort, including cosponsoring two national workshops (Smoke Management and Fuels Management), has increased application of such burning in Pacific Northwest manyfold. Coordination with U.S. Department of Energy (DOE) and Bonneville Power Administration was established to provide a multi-agency planning force to study use of forest biomass for production of energy. DOE and Forest Service initiated joint study in northeast Oregon to determine economic feasibility of harvesting dead lodgepole pine resulting from bark beetle epidemic for products and fuel. Field work completed and plan report in 1980. As an aid to improving the land managers ability to administer forest residue disposal contracts, a computer-based system for residue prediction and hazard appraisal was written, documented and implemented. Also, new techniques for hazard appraisal and for making fire management inputs into land use planning were prepared.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0049
ECONOMIC FEASIBILITY OF HARVESTING DEAD LODGEPOLE FOR PRODUCTS AND FUELS
Inman R, Pacific Northwest Forest & Range Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Portland, Oregon, 97208,* (XR 9 8188 01)
OBJECTIVE: The objective is to evaluate the economic feasibility of converting standing dead and down timber of small diameter to a combination of products and fuel. Specific goals are: (1) to obtain costs and production rates for harvesting dead lodgepole pine timber with existing equipment; (2) to determine the value per acre of the products and fuel; and (3) to evaluate land-management credits for fire-hazard reduction, site preparation, and habitat protection. Tasks are: (1) to determine the economic feasibility of producing sawlogs and fuel from dead lodgepole in northeastern Oregon; (2) to provide a production and cost data base that can be used for assessing the feasibility of utilizing dead timber under different conditions; (3) to contribute knowledge of the effects of mechanized whole-tree logging on nutrient balances, soil compaction, and other environmental concerns; (4) to demonstrate a methodology that may be followed in evaluating economic feasibility of harvesting residues in other forest types; (5) to demonstrate the benefits of whole-tree harvesting of dead timber in providing wood for energy and achieving land-management goals; and (6) to identify opportunities for modifying the

harvesting system to further reduce costs or increase the value of the output.
SUPPORTED BY: U.S. Dept. of Energy.

5.0050
TIMBER QUALITY AND PRODUCT YIELD POTENTIAL OF WESTERN SOFTWOOD RESOURCES
Woodfin RO, Pacific Northwest Forest & Range Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Portland, Oregon, 97208*, (PNW-3101)
OBJECTIVE: Determine, evaluate, predict, and describe product yield potential and utilization characteristics of western softwood timber as an aid to resource utilization.
APPROACH: Product yield potential of standing dead timber, logging residue, and material below merchantable limits will be developed on a species by species basis. Study will determine resource characteristics, rates of dead timber deterioration, and aboveground biomass. During the next 5 years, study will emphasize the utilization of standing dead timber caused by recent major insect infestations. Up-to-date recovery information and analytical grading systems will be developed to meet Forest Service and industry needs for data that reflect mill technology and resource changes. Emphasis will be given to major species that require product recovery on a cubic volume basis. Log and tree grades will be completed on species having systems considered inadequate for estimating value and yield. Studies will relate physical timber characteristics to yields. Western hemlock, the true firs, young growth ponderosa pine and western red cedar will receive primary attention.
PROGRESS: Progress in utilization of dead western softwood timber will be through resource needs and an understanding of product potential, losses and problems for dead timber. Without that awareness, utilization may proceed slowly. Chipping and fuelwood are only partial answers to utilization of the estimated 6 billion b.f. of salvageable timber. Lumber is expected to be a key product. Research is correlating tree and stand condition with losses in value and volume to guide management decisions on utilization of dead timber. Some losses are less than expected. As a percent of tree cubic volume, dead grand fir recovered only 5 percent less lumber than live trees. For white pine, the recovery was 8 percent less. Recovery and losses are closely related to time since mortality. Standing dead timber has losses from logging and handling, decreased lumber volume from logs sawn, and degrade of lumber due to deterioration related defects. Staining is one of the significant causes of dead timber lumber degrade. The western softwood resource is changing in size and quality, new processing technology has been introduced, and product item mixes change. These require management tools in the form of product yields for log allocation and utilization decisions by industry and public agency alike.
SPONSORED BY: U.S. Dept. of Agriculture, Forest Service.

5.0051
SCREENING POPULUS SPECIES BIOMASS FOR USE AS A SOURCE OF ENERGY
Bowersox TW, Blankenhorn PR, Dept. of Forest Resources, Pennsylvania State University, *University Park, Pennsylvania, 16802*, (PEN02488)
OBJECTIVE: Collect wood and bark specimens of 1, 2, and 4 year old biomass from first and second rotation of 3 parentages growing on 2 site conditions; determine grass heat of combustion, nutrient content and chemical composition of the biomass; analyze and evaluate within and among parentage variation, as a function of age and rotation of populus hybrids grown on the two sites.
APPROACH: Factorial design of two site conditions, three parentages, two rotations and three ages of wood and bark will be used to evaluate the variation in energy and chemical values associated with each factor.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0052
WOOD AS AN ENERGY SOURCE IN THE RURAL-URBAN COMPLEX
Gould W, Brown J, McKiel C, Agricultural Experiment Station, University of Rhode Island, *Kingston, Rhode Island, 02881*, (RI00960)
OBJECTIVE: Determine the potential demand for fuelwood in the southern New England rural-urban complex. Evaluate the productivity of typical sites for growing fuelwood. Assess ways to more efficiently use the resource by determining practical methods of seasoning wood.
APPROACH: Several even-aged stand sites will be selected to include well-drained, moderately well-drained, and poorly drained locations. Cordwood biomass productivity of each stand will be determined by sample plots. Individual trees will be randomly selected by diameter-class for destructive sampling. Root systems of several sample trees will be examined for sprout vigor and tree origin. Fertilization to increase growth rates will be evaluated. Trends in fuelwood consumption will be determined. Various aspects of wood seasoning will be investigated.
PROGRESS: Fuelwood biomass was determined for well drained and moderately well drained site categories. Three study areas were delineated from each drainage category and a total of 12/0.0405 ha plots were established for such standard tree measurements as dbh, basal area and total heights. Two hundred trees, selected according to dbh classes were cut and the bole and branch wood to a minimum diameter of 2.54 cm were weighed fresh. Two hundred sample disks taken from various heights of each tree stem, were weighed fresh and then weighed oven-dry. A complete soil analysis was conducted for each soil drainage category. Plot, soil and tree data were analysed. Interpretation is incomplete; preliminary results indicate that some 40 year old mixed oak coppice stands produce nearly a cord of wood per acre per year. Oak fuelwood drying is being studied in regard to effect of time of cutting and degree of weather protection. Wood samples are placed in drying racks (0.27 mue3 capacity) and periodically weighed to determine moisture content. At this time, six racks (N = 12) have been filled and are being monitored. Data on fuelwood demand have been collected and analyzed by telephone survey. Results indicate that 23% of urban/urban-suburban households and 48% of rural/rural-suburban households burned firewood during the study season. Households heating with electricity as the primary heat source used more than did users of fuel oil or natural gas.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0053
RHODE ISLAND INTENSIVE FOREST MANAGEMENT AREA PROJECT
Gould WP, Brown JH, Husband TP, Dept. of Forest & Wildlife Management, University of Rhode Island, *Kingston, Rhode Island, 02881*, (RI-RD-3)
OBJECTIVE: Educate the small Rhode Island forest landowner as to the production potential of the common forest types and appraise him of intensive management procedures that are consistent with landowner objectives and aesthetic considerations. Landowner management objects are maximum fuelwood production and/or integrated optimum product management.
APPROACH: Establish three research/education intensive management plots to show production potentials and appropriate management techniques. The plots will be analyzed, marked and harvested to illustrate goals and procedures. Workshops will be held for small landowners and youth group workers (4-H leaders and teachers). Publish Extension educational publications relative to these and other research findings. Evaluate the research and educational aspects of the project.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0054
FOREST BIOMASS STUDIES
Hitchcock H, Div. of Land & Forest Resources, U.S. Tennessee Valley Authority, *Norris, Tennessee, 37828*
OBJECTIVE: This ongoing project has as its objective the evaluation and analysis of woody forest biomass as related to energy and traditional forest products. The project has two components: (1) construction of individual tree weight equations for forest species, and (2) development of operational biomass inventory techniques. Emphasis is on interagency cooperation.
SUPPORTED BY: U.S. Tennessee Valley Authority.

5.0055
IMPROVEMENT AND DEMONSTRATION OF HARVESTING TECHNOLOGY AND METHODOLOGY
King WW, Koger JL, Div. of Land & Forest Resources, U.S. Tennessee Valley Authority, *Norris, Tennessee, 37828*, (880-43-10)
OBJECTIVE: To develop workable harvesting machinery support and business systems for efficient removal of wood for energy use. To increase the volume and value of our harvested timber crops thereby increasing the stumpage return on landowner's investments. To improve the overall efficiency and cost effectiveness of the Valley's sawlog and pulpwood logging industry while concurrently protecting the land and water. To improve the present forest industry workers' lot. To train and certify new workers and timber harvesting managers for careers in timber harvesting.
PROGRESS: Published report on factors affecting the production of rubber tired skidders. Another study on factors affecting the cost and construction of logging roads was completed and the report is in press. Fieldwork is underway on two other studies: Factors Affecting the Cost of Felling, Limbing, and Bucking Trees With Chainsaws and Factors Affecting Truck, Rail, and Barge Cost of Round Wood. A study on sawlog salvage from low-grade tree-length chipwood will be completed and reported as a Masters Thesis.
SUPPORTED BY: U.S. Tennessee Valley Authority.

5.0056
MARYVILLE COLLEGE PYROLYSIS PROJECT
Klein EL, Jolly M, Div. of Land & Forest Resources, U.S. Tennessee Valley Authority, *Norris, Tennessee, 37828*
OBJECTIVE: This project is to make oil, gas, and charcoal from dry industrial or forest hardwood and softwood residues.
APPROACH: A mobile pyrolysis unit has been obtained for testing. Dry residue enters a reactor chamber where heat is applied. This causes a gas to form which can be burned in a combustion chamber. The gases can also be routed through a condensor where oils can be obtained and the remaining gases can then be burned to provide heat. If oxygen is restricted from the reactor chamber the wood becomes charcoal after the gases are driven off. The charcoal has a present market value of about $75 per ton.
PROGRESS: The present investigative work includes 1) determining temperature and dwell time in the reactor chamber, 2) proper condensing temperatures, 3) Btu content of oils and gases obtained at different temperatures, 4) chemical composition of these oils and gases, 5) the commercial application of the mobile unit in both the mobile and stationary mode.
SUPPORTED BY: U.S. Tennessee Valley Authority.

5.0057
ECONOMICS OF CHIP HARVESTING SYSTEMS IN THE SOUTH
Massey JG, Hickman CA, Agricultural Experiment Station, Texas A & M University, *College Station, Texas, 77843*, (TEX06301)
OBJECTIVE: Identify the market potential for wood chip use in the paper, fiberboard, and energy-related industries in Texas and in the South. Determine the level of fossil fuel price at which wood chips become economically feasible for various technologies in chip production. Assess the probable impacts of a wood chip energy market, coupled with the paper and fiberboard markets, on economic returns to the forest landowner and Texas' and the South's future timber supply.
APPROACH: Through literature and survey determine wood input mix to the paper, fiberboard, and energy industrial markets. Survey the off-site chipping technologies. Develop off-site chipping economic data. Survey the on-site chipping

technologies. Conduct time studies to define the production functions for the various chipping methods. Develop and test a simulation model to determine the effects of various levels of labor and capital inputs on the chip, energy, and product outputs from the chip harvesting systems.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0058
CHEMICALS AND ENERGY FROM FORESTRY AND RELATED RESIDUES
Soltes EJ, Agricultural Experiment Station, Texas A & M University, *College Station, Texas, 77843,* (TEX06279)
OBJECTIVE: Identify and address technical and economic constraints in residue utilization. Identify and develop processes for producing chemical and energy products from residues. Evaluate various preprocessing schemes to enhance residue utility in product generation.
APPROACH: Assess and address biomass availabilities; harvesting and transportation problems. Evaluate pyrolysis as a means of generating clean, volatile fuels from dirty residues. Characterize products of pyrolysis of various residues. Identify and develop pyrolysis parameters and post-pyrolysis processing in maximizing yield of useful products and intermediates. Evaluate the effects of composting and other processes on residue utility.
PROGRESS: The characterization of pyroligneous products may permit development for future chemical industries from the biomass base. The Tech-Air pyrolysis oil has been further characterized. New information includes the identification and quantification of the major phenolic components, and confirmation that acetic and formic acid concentrations in the oil are responsible for its corrosivity. It is becoming apparent that utilization of this oil will require prior fractionation to yield fractions with similar chemical or physical properties, or processing to alter the chemical complexity. Current work includes the evaluation of adhesives produced from formaldehyde condensations with the phenolic fraction, and the identification of processing requirements to produce a diesel fuel from the oil. Work on the laboratory pyrolysis reactor was delayed, but it is now essentially completed, and the reactor will be used soon in the evaluation of biomass feedstocks for pyrolysis. Laboratory efforts to develop quantitative lignase test via the syringaldzine reaction were suspended due to lack of progress. Some work has been initiated in differentiating the effects of T. viride cellulase activity versus rumen microorganism activity on a forage grass. Several reports were written on the biomass residue resources of Texas and their energy potentials, as well as two treatises on pyrolysis.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0059
QUALITY HOUSING ENVIRONMENT FOR LOW-INCOME FAMILIES
McKown C, South Plains Research & Extension Center, Texas A & M University, *Lubbock, Texas, 79401,* (TEX02952)
OBJECTIVE: Identify housing related aspirations, expectations, needs, and satisfactions of low-income families and examine limitations to the attainment of quality housing.
APPROACH: Random sampling within low income counties will be conducted. Regional data will be analyzed involving energy use, housing satisfaction, and demographic characteristics of the population.
PROGRESS: The objectives of the project were to analyze housing conditions, aspirations, and constraints of low-income families. Findings indicated the housing condition in rural areas was comparatively worse than in urban areas. The rural population was older, more stable, and less willing to move from present location than the general population. Housing aspirations were for low-interest, home improvement loans. Community services (roads, sewer, water) are also needs. Analysis of energy data indicated that a large percentage of income was spent on fuel for the household. Families were attempting to find alternative energy sources primarily wood. Energy consumption and housing conditions correlate. About half the houses in the survey had no insulation. Respondents indicated that they were satisfied with rural living but the primary reasons were environment, not housing. However, housing inadequacy as measured by lack of crowding and indoor bath facilities were strong predictors of satisfaction with the living environment. Single family units in farm/or on farm rural locations comprised the majority of dwellings. Among the major constraints to the improvement of low housing quality within the rural sector are low incomes, lack of available housing services, and lack of technological skills.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0060
RESOURCE EVALUATION
Van Hooser DD, Intermountain Forest & Range Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Ogden, Utah, 84401,* (INT-4101)
OBJECTIVE: Maintain a continuing assessment of the renewable resources situation for forest and rangelands, in the Rocky Mountain Resources Evaluation Region, including analyses of supplies and demands at local, state, and regional levels. Develop solutions to related problems of data collection, compilation, and analysis. Provide technical leadership and coordination in the development of resource information required for national resource assessments, planning the management of forest and rangeland, and developing programs and policies.
APPROACH: Conduct a series of interrelated studies designed to provide, through analysis and interpretation of available data, the information needed for comprehensive analysis of forest and rangeland resources. Emphasis will be on surfacing critical issues affecting the use and management of these resources. Acquire data, either qualitative or quantitative to address these issues, and encompass a broad array of variables e.g., area occupied by forest and rangeland; quantities, and conditions of timber stands; land ownership; treatment opportunities; timber removals; importance of timber products, and nontimber uses. Broaden the scope of inventory and evaluation from a single to multiple resources. The conversion to multiresource evaluation may be through interaction of inventories for other resource data with existing timber inventory requirements. The scope of demand studies will be broadened to include forest and rangeland resources other than timber.
PROGRESS: Forest area and timber statistics have been published for three working circles, one in Montana and two in Utah. These provide up-to-date interim information to planners and managers util the state reports are published. A computer program, POTIM, was developed to calculate potential available timber output from a working circle. Input required is management cost and expected yield information over a specified rotation. The program allows planners and managers to estimate available annual timber output for specified management budget and nontimber forest use impacts. A computer program, BREX, has been developed and published. The program is for applying ridge regression techniques to multiple linear regression. Gross cubic-volume tables have been developed for pinyon and juniper trees in New Mexico.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0061
MAPLE PROCESSING EQUIPMENT AND RELATED PROBLEMS
Laing FM, Morselli M, Dept. of Botany, University of Vermont, *Burlington, Vermont, 05401,* (VT00264)
OBJECTIVE: Investigate modifications to conventional open-pan evaporators which will provide greater economic efficiencies. Investigate and evaluate other processing equipment which might be applicable to maple processing. Investigate quality control performance of units researched for comparison with conventional evaporator output.
APPROACH: Test of automatic feed wood chip fueled maple syrup evaporator. Engineering and cost efficiency of different wood fuel types and implications to equipment modification. Economic and engineering efficiencies of modified preheaters installed on conventional evaporator systems. Engineering and economic efficiency analyses of vapor compression distillation, redesigned for processing sugar solutions. Characterization of flavors and off-flavors with taste panels, chemical and physical analyses, as affected by variables associated with maple syrup products manufacture.
PROGRESS: The tubular sap pan was continued in operation to further test modifications. Further design changes to facilitate fabrication are planned. Wood chip fuel designs are complete. Tests of pelletized wood residue fuel have been delayed pending location of a commercial pelletizing plant. Preliminary work on a 2-stage evaporative system was started. In lieu of a complete installation in situ, sap was evaporated to 10 degrees Brix in the tubular unit, further concentrated to 50 degrees Brix in a dairy type vacuum evaporator located in the Dairy Sciences Building and brought to completion in a gas-fired finishing pan. The product was judged excellent in quality. In an integrated system, steam from the conventional evaporator would be used as a heat source for the vacuum unit. The tests were run with units of unequal capacities, therefore economic analyses were not feasible but results to date warrant further work. The system should provide significant energy savings.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0062
MAPLE SYRUP PRODUCTS MARKETING AND WOOD ENERGY RESEARCH
Garrett LD, Huyler NK, Sendak PE, Northeastern Forest Expt. Station, University of Vermont, *Burlington, Vermont, 05401,* (NE-4207)
OBJECTIVE: Define wood resource economic availability, growth, harvest, processing, utilization, and market methodologies necessary for economic use of wood fuel for home and institutional space heat, industrial heat and power, and electric generation. For the maple products industry: develop effective quality control methodology for improved sap, syrup, and sugar products; develop improved processing systems and develop new products to permit market expansion.
APPROACH: Conduct studies to evaluate existing and projected biomass and existing and projected wood waste from harvesting and processing; develop economic models to relate cost parameters associated with spatial location of wood resource to energy needs of the community and industrial components. Compare existing harvesting systems with large and small mechanized chipping systems, small high-lead or sky-line crane logging systems, and specially adapted all-terrain, small integrated logging systems. Analyze marketing methods for delivering wood fuels directly or through marketing intermediaries to various end users. Evaluate market implications of differing wood fuels, including solid, chipped, and pelletized wood fuel products. Develop economic analysis of wood as an energy alternative for home and institutional space heat, industrial heat, and power and electric generation. Develop area, regional, and national profiles on saps and syrups to provide evaluations of factors contributing to the development of color and flavors in syrups and sugars.
PROGRESS: A cost analysis of processing maple sap to syrup for oil-, wood-, and LP gas-fired evaporators indicates that: fuel, capital, and labor are the major cost components of processing sap to scale in processing sap to syrup. A study using wood chips as a fuel for maple sap evaporators found that the chips are a feasible fuel. Combustion tests of wood chips gave good results at fuel moisture content less than 35 percent. A laboratory experiment was used to test marketing strategies for pure maple syrup. Effects of price, product grade, and point-of-purchase information were tested. A method to estimate the potential number of maple taps for sap production from forest survey data was developed and tested. Work to detect activated charcoal filtration of pure maple syrup (quality control) by gas chromatography is continuing.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0063
ANALYSIS OF THE FUELWOOD MARKETING AND DISTRIBUTION SYSTEM IN VERMONT
Bousquet D, School of Natural Resources, University of Vermont, *Burlington, Vermont, 05401*, (VT00036)
OBJECTIVE: Identify and describe the physical structure and function of the existing fuelwood marketing and distribution system in Vermont. This will include definition of producer, product, channel and ultimate consumer characteristics and requirements. Evaluate the economic performance of the fuelwood processing system. This will include analysis processing, efficiency, costs and returns, and costs of fuelwood delivered to consumers.
APPROACH: For fuelwood producers: Direct personal interviews and direct measurement of process variables - labor; machine and investment costs for different types of producers. Emphasis is on defining organization problems, and characteristics and potentials. Functions include: fuelwood harvesting, "manufacturing", inventory, measurement and storage, transportation and delivery. Methods and time study; energy balance; R.O.I.; analysis of delivered cost to consumer. For fuelwood consumers: direct personal interviews with cooperating "urban" and "rural" consumers, utilizing direct and coded questionnaires; direct area selection stratified after sampling. Specify situation regarding species, form, size, volume, seasoning, storage and delivery, seasonal demand; type of end use; pricing; costs.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0064
TIMBER MANAGEMENT (CFR MANAGEMENT PROGRAM)
Schreuder GF, School of Forest Resources, University of Washington, *Seattle, Washington, 98195*, (WNZ-M2-02)
OBJECTIVE: This program area is concerned mainly with the planning and techniques for long-term management of forests for timber production, theory and methods of mensuration for estimating timber growth, yield and quality, cultural techniques including thinning, fertilization and prescribed burning, protection of the forest resource against wildlife, selection and breeding superior trees.
APPROACH: Methods used include computer modeling and field studies of permanent plots.
PROGRESS: Research is continuing as follows.An initial module of a six-module program to provide mid-career upgrading of ranger district silviculturalists, equally shared by UW and Ore. St. Univ. Five acres treated with nitrogen fertilizer in 0,200, and 400 lbs/acre. Diameters and heights of trees remeasured. Set of input-output multipliers was developed through use of secondary sources of data and an analytical procedure based on Bur. of Economic Analyses Regional Impact Multiplier System. Remeasurement of plots that had been: fertilized and thinned; fertilized with urea and ammonium nitrate; summary and analysis of this data; plots to test fertilization and herbicide application. Estimate recent trends and identify factors promoting wood fuels utilization is underway. Resurvey of sample plots; operation of magnesium plant; establish SO(2) damage threshholds; needle retention and sulfur content analysis developed. Research carried out to investigate timber inventory management supply and dependent communities: timber sale data; complex economic linkages; uncut inventory; role of timber purchasers; dependence of mills on sales considered.
SUPPORTED BY: Washington State Government.

5.0065
HARVESTING, PROCESSING AND MARKETING OF FOREST PRODUCTS (CFR MANAGEMENT PROGRAM)
Schreuder GF, School of Forest Resources, University of Washington, *Seattle, Washington, 98195*, (WNZ-M2-04)
OBJECTIVE: This program area is concerned mainly with the study and development of harvesting and transportation systems, the anatomical, mechanical, physical and chemical properties of wood and its components, the manufacturing and utilization of wood and related products, effects and control of fungi, insects and other agents on wood, the economics of timber production, harvesting and processing of forest products, the study of institutional management and legal constraints in timber production, harvesting and manufacturing of forest products, the marketing of forest products, grading and conversion rules and standards, supply, demand and price analysis and forecasting.
APPROACH: Research methods utilized include: computer simulation of future markets for forest products, future supplies of forest products, and transportation systems; laboratory testing of wood properties; electron microscopy; field investigations of properties of wood products such as fiberboard, press board, glues and resin uses, etc.
PROGRESS: Results show that low pH resins were unsatisfactory as adhesives; best results with 10% level of phenol replacement by the precipitated kraft mill lignin. Research to examine role of wood residues and forest biomass as a source of energy is initiated. A study of the interrelationship of variables which influence the operation of gravity-outhaul skyline system is in progress. A study of the dynamic behavior of skyline logging systems is initiated. Estimates of timber supply based on physical existence of standing timber exaggerate the amount of merchantable wood available. Limitations imposed by harvesting technology and market prices exclude the material from commercial exploitation. Parallel laminated veneer panels analysis show that Tension-Lam grades produces from 1/8- and 1/10-in veneer C grade has no apparent effect of width in elasticity, rupture, or tension stress. Price estimates of 6 primary forest products indicate that price has a short yet delayed influence on quantity demand. Confidence intervals for estimates are wide; long- and short-run elasticities examined; models formulated for the products. Use of agricultural residues (rice straw, grape vine twig fibers, coconut husk, kraft pulp mill reject fibers) to make corrugated roofing material for low-cost housing continued. Method developed to make material waterproof, durable, stiff, and stronger.
SUPPORTED BY: Washington State Government.

5.0066
QUALIFICATION OF BIOMASS FOR USE AS FUELS FOR ENERGY PRODUCTION
Smith R, School of Forest Resources, University of Washington, *Seattle, Washington, 98195*, (WNZ00048)
OBJECTIVE: Develop a physical-chemical characterization of various hog fuels to be used as reference fuels including the estimation of fuel variability; characterize logging residues and thinnings from a physical-chemical perspective which will help determine the effort which can be spent on their extraction and transportation; develop a physical-chemical characterization for energy fuel-farm grown materials.
APPROACH: A) Characterization of wood fuels by source and species, B) source and species: wood fuel composition will vary depending on its source, C) physical-chemical values developed: partical size distribution, moisture content, heat content, bulk density, proximate analysis, elemental analysis, D) data analysis will be divided into two major categories: 1) within a given fuel type and 2), between fuel type. Eight months each will be required for characterization of hog fuel, logging and thinning residues, and energy fuel-farm material.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0067
EVALUATION AND MODELLING OF BIOMASS YIELDS FROM CONIFER STANDS IN INLAND NORTHWEST
Chapman RC, Baldwin VC, Burnell DG, Dept. of Forestry & Range Management, Washington State University, *Pullman, Washington, 99163*, (WNP00426)
OBJECTIVE: Development of individual tree biomass equations for each of the major softwood species in the Inland Northwest. Development of statistical models to describe the distribution of biomass within a stand for each tree component (boles, branches, and foliage) based on a variety of utilization standards (top diameters), and the accumulation of biomass over time. Modification of existing volume simulators or development of new simulators which can be used to evaluate many alternative energy production strategies such as optimum species selection and composition and selection of appropriate silvicultural treatments.
APPROACH: Stand representatives of species combinations, age classes, and habitat types will be sampled in the field, and lab determinations made of oven dry yield. Statistical models will be designed to provide distribution of biomass within a stand for each tree component. These models will be used to strengthen existing volume simulators or if necessary for the development of new simulators, to evaluate alternative energy production strategies.
PROGRESS: Two hundred and twenty trees were destructively sampled on 35 sites in northeastern Washington. Bole disks and branch samples were collected and transported to Pullman for drying. Field data is being edited and key punched. A computer program has been written to edit tree data and create data files. Working is beginning on development of a program to evaluate different estimation techniques for needle and branch biomass. Work has begun on evaluating the structure of the "Growth Prognosis Model", a computer program of stand growth. Preliminary green weight models have been developed for the bole and the crowns of Lodgepole pine, Ponderosa pine, Larch, and Douglas-fir. A preliminary reconnaissance survey has been made to locate areas with severe Spruce budworm infestations in north central Washington. During the 1979 season the area will be sampled to obtain data necessary to model the changes in yield and understory development associated with Spruce budworm defoliation.
SUPPORTED BY: Washington State Government.

5.0068
THE SOCIAL ECONOMY OF ENERGY: CONSEQUENCES AND ALTERNATIVES FOR LOW INCOME FAMILIES IN WISCONSIN
Tienda M, Dept. of Rural Sociology, University of Wisconsin, *Madison, Wisconsin, 53706*, (WIS02323)
OBJECTIVE: This research addresses the fundamental question of how low-income rural families adjust to continued energy price increases. Answer to this question requires a focus on the structural and behavioral aspects of family life to illustrate how the energy crunch is manifested among low-income rural families; the potential limits to the cost-absorbing capacity of low income families; and the various strategies used by the economically disadvantaged to accomodate rising energy costs.
APPROACH: Establish the flexibility of poor households to cope with the energy crunch, a sample of low-income rural households will be interviewed by telephone. Information about energy usage patterns, physical features of the dwelling, socioeconomic characteristics of the family and other structural constraints solicited. The social impact of rising energy costs will be assessed by documenting specific compensatory reactions which reflect coping behavior to energy prices in a stimulus-response analytic framework.
PROGRESS: Approximately 300 residents of nonmetropolitan counties in Northeastern Wisconsin were randomly selected and interviewed by phone to ascertain information about their experiences with the changing cost and availability of energy. Preliminary results indicate that only 4% of all respondents considered energy efficiency an important criterion in the selection of their present homes whereas price was considered important by 88%. Utility gas and fuel oil are the most frequently used fuels for space heating, but 17% of the respondents use wood as the primary fuel for home heat. Over 45% of all respondents used alternative fuel sources for heating, of which 63% used wood as the secondary fuel. Wood use for space heating is more pronounced in those counties with no urban population. Regarding the social consequences of energy shortages on family lifestyles, respondents' reported (1) decreases in physical comfort levels; (2) decreases in economic well-being; (3) forced use of alternative, less expensive fuels; and (4) increases in home conservation and retrofitting practices. Only 34% of all respondents indicated that changes in the cost and availability of energy had no impact on their lifestyle. Most respondents did not know how they could further

reduce the regressive impacts of higher energy costs except through political action.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

5.0069
ENERGY AND CHEMICAL PRODUCTION FROM WOOD RESIDUES
Hajny GJ, Springer EL, Baker AJ, Forest Products Lab., U.S. Dept. of Agriculture, Forest Service, *Madison, Wisconsin, 53705,* (FPL-3409)
OBJECTIVE: Foster efficient use of wood residues for chemicals and energy production by providing authoritative evaluation of available technology and developing improved techniques for chemical and biochemical conversion and fuel uses of wood.
APPROACH: In the area of chemicals, three subjects will be investigated: the fractionation or solubilization of wood components, the hydrolysis (saccharification) of cellulose, and the further conversion of saccharification products to more useful materials. The first year's work will include critical reviews of available technology and of past research findings. On the subject of wood fuels, a summary review of past work at the Forest Products Laboratory will be prepared. Next, updated reports on technology for briquetting and charcoal production will be published.
PROGRESS: Whole-tree chips have been used in pulp production and are now being considered as an alternative to fossil fuels by forest products industries as well as smaller power plants. Storage of chips at these plants is necessary to avoid shutdowns due to nondelivery of chips caused by bad weather, strikes, or other situatuons. Simulators of chip piles were used to study the storage characteristics of loblolly pine whole-tree chips and evaluate methods for reducing storage losses. Whole-tree chips generated significantly more heat and thus achieved higher pile temperatures than did clean debarked chips. After 6 months' storage, wood substance loss was much higher for whole-tree chips than for clean chips. After storage the higher heating value of the stored chips, expressed on a per pound ovendry wood basis, had not changed. Thus, the loss of fuel value of the stored chips in directly proportional to the loss of wood substance. Treatment of the chips by immersion in a dilute aqueous solution of formaldehyde and p-nitrophenol effectively preserved the chips during 6 months' storage, but is probably not cost-effective for chips stored for fuel. A desirable goal of the forest product industry is less reliance on purchased energy from fossil fuels and increased use of fuel wood collected with the normal timber harvest. The forest products industry could then approach the ideal of being an industry based on solar energy for both it production of raw material and its energy.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

5.0070
DEVELOPMENT OF AN EFFICIENT WOOD BURNING FURNACE
Zien HB, Performing Institution Not Reported.
OBJECTIVE: The purpose of this work is to develop a wood burning furnace that does not generate creosote or residue. The technology employs advanced combustion concepts. The DOE funds will be used to perfect the technology, develop a working model, and initiate a testing program.
SUPPORTED BY: U.S. Dept. of Energy.

5.0071
HOME ENERGY SYSTEMS AND CONSERVATION
Pochop LO, Borrelli J, McNamee M, Dept. of Agricultural Engineering, University of Wyoming, *Laramie, Wyoming, 82071,* (WYO-164-080)
OBJECTIVE: The main objective is to obtain performance data on home woodburning units as actually operated by homeowners. Specific objectives include: determining the efficiency of woodburning units, surveying the extent of use of woodburning units, and developing guidelines for the operation of woodburning units. The study is designed to measure the variability between various types of units as actually used and during different times of the year.
APPROACH: Cooperators will be selected as randomly as possible and the efficiencies of their woodburning units will be measured under conditions of normal operation. An energy balance for each unit will be determined from the temperature and volume of air passing through the flue and initial energy content of the wood burned.
SUPPORTED BY: Wyoming State Government.

5.0072
BACK PRESSURE DRYING
Hedstrom BO, Dept. of Chemical Engineering Design, Chalmers Tekniska Hogskola, *Goteborg, Sweden, S40220 Goteborg 5,* (53 1260 091)
OBJECTIVE: To develop a system for processing moist log fuels such as bark, peat, and forest biomass, comprising mechanical dewatering, disintegration, and steam drying. Our target is to optimize the net energy production from the combustion of a limited amount of fuel.
APPROACH: A prestudy has shown the importance of a continuous working pilot plant. In pilot scale design data and certain main problems can be studied. As soon as possible (1981) we hope that a full scale plant can be errected to demonstrate our technique. There is urgent need for new techniques to utilize internal fuels in our Swedish forest industry. Many mills are also planning to use peat. Later our technique can be valuable also for municipal heat and power generation. So far, our results show that pulverized fuels can be used in oil heated boilers without any expensive modifications.
SUPPORTED BY: Namnden for Energiproduktionforskning.

5.0073
MEANS OF SUPPLYING FOREST ENERGY
Lonner G, Interforest AB, *Lidingo, Sweden, S18122 Lidingo 1,* (53 1160 86)
OBJECTIVES: Systematize, describe, and quantify means of supplying forest energy. Analyze development bottlenecks for forest energy in Sweden.
APPROACH: Desk studies of performed research and development focused on Sweden, Finland and USA. Interviews of involved research and development personnel. The study includes the following phases: 1) Systematizing of all possible means of supplying forest energy. 2) Mapping and description of knowledge, methods and techniques for the various means of supplying forest energy. 3) Analysis of the potential of various means in the energy supply for Sweden. 4) Analysis of bottlenecks for the development and proposal for future resource requirements to remove these bottlenecks.
SUPPORTED BY: Namnden for Energiproduktionforskning.

5.0074
TERMINAL SYSTEM FOR HANDLING FORESTRY ENERGY, PEAT AND WASTE
Hedman N, Wiman O, Norra Smalands Energigrupp AB, *Nassjo, Sweden, S57100 Nassjo,* (53 1160 771)
OBJECTIVE: Investigation of the proper number, optimal size and location of terminals for forest energy, peat and waste in northern Smaland. The eight local authorities, which are shareholders of Norra Smalands Energigrupp AB, will use the investigation results to speed up the changeover to fuels other than oil and reduce the dependence upon oil from 67% at present to 43% by 1990.
APPROACH: Study of a) the capacity of main roads and need of strengthening, if any; b) the capacity of railroads and need of extension, if any; c) needs of construction for connection to main roads and railroads in different terminal locations; d) need of transporting vehicles of proper design; e) need of railway trucks of proper design; f) costs of main road transport; g) costs of railway transport including costs for unloading at and transport from railway station to consumer; h) cost comparison between two or more alternatives for the number and location of the terminals; i) optimal size of terminals with regard to transportation economy; j) suitable location of terminals with regard to ground conditions and owners of land; k) effects on the labor market; and l) environmental influence. Proposal for location of terminals includes analysis of the sensitivity of changing in the rate of interest, costs of labor and transport costs.
SUPPORTED BY: Namnden for Energiproduktionforskning.

5.0075
WOOD ENERGY - SOURCES AND USAGE BASIS FOR 1981-1984
Hardell R, Liljequist U, Magnusson L, Gustafsson B, Schuster R, Sikob AB, Ingenjorscentrum, *Sollentuna, Sweden, S19178 Sollentuna,* (53 1160 851)
OBJECTIVE: The object of the study is to give a systematic description of systems for recovery, harvesting, transportation, conversion, and final use of wood energy and products from wood energy, and to analyze possibilities of technical and economic development, giving a basis for the plans of the National Swedish Board for Energy Source Development for the period 1981-1984.
SUPPORTED BY: Namnden for Energiproduktionforskning.

5.0076
DEVELOPMENT OF SECONDARY TRANSPORTATION SYSTEMS FOR THE UTILIZATION OF FOREST ENERGY
Larsson M, Forskningsstiftelsen Skogsarbeten, *Stockholm, Sweden, S11360 Stockholm,* (12/80-82)
OBJECTIVE: A recent joint Government-Forest Industry project concerning whole-tree utilization has indicated great potentials for additional raw materials for fiber and energy purposes. However, the properties of these new assortments - such as low bulk density and high degree of contamination - create many new problems. The economic effects of these are especially noticeable in the secondary transportation phase of logging. The chief objective of this project thus is to establish the needs and specifications for future technical and organizational development of transportation systems for these new assortments.
APPROACH: On the basis of data from a number of field studies a variety of transportation systems will be simulated by computer and analyzed.
PROGRESS: Previous phases of this project (E8/78-82 and E 15/79-82) have indicated great potentials of recovering logging residues for energy purposes. This, however, implies integrated logging of wood for energy and industrial purposes i.e., new logging systems. Continued work within this project therefore focuses on such new assortments that may be anticipated in future logging practices involving centralized processing of full trees or segments of trees. The results should give: 1. Government and industry parts of the basis for evaluating the accessibility of new raw materials for fiber and energy; 2. Manufacturers a basis for the development of transport equipment; and 3. Operators a basis for choosing between and making the most efficient use of equipment already available.
SUPPORTED BY: Transportforskningsdelegationen.

5.0077
WOOD BURNING AND THE PRODUCTION OF PARTICULATE MATTER (FLY ASH)
Peterson F, Division of Heating & Ventilation, Kingliga Tekniske Hogskolan, *Stockholm, Sweden, S10044 Stockholm 70,* (791226-6)
OBJECTIVE: The objective of this project is to determine the amount of fly ash emitted from smaller wood-fired boiler installations. The amount of fly ash emitted by different fuels, different stoking systems, and different methods of operation will be determined, as will physical properties of the ash of importance for ash separation and atmospheric effects. Measurements will be made both in the laboratory and in the field.
SUPPORTED BY: Statens Rad for Byggnadsforskning.

5.0078
BIOCONVERSION - ENERGY FORESTRY
Schuster R, Fjarrvarme AB, *Trosa, Sweden, S15013 Trosa,* (53 1360 312)
OBJECTIVE: The project includes production of project proposals for the International Energy Agency program "Energy Forestry" and supporting activities in the initiating phases of these projects.
SUPPORTED BY: Namnden for Energiproduktionforskning.

5.0079
THE ENERGY FORESTRY PROJECT (EFP)
Siren G, Christersson L, Linder S, Perttu K, Energy Forestry Project, Swedish University of Agricultural Sciences, *Uppsala, Sweden, S75590 Uppsala,* (53 3065 015)
OBJECTIVE: To create and collect knowledge of resistant fast-growing clones acceptable to regional variation of biotopes, to develop scientifically based production methods by optimizing abiotic, biotic, and cultivation technical premises for enabling dry matter production exceeding 20 ton.ha-1.yr-1 DM. To establish clonal cutting orchards for large scale experiments, to collect and scrutinize experience on energy forestry for compiling instructions about soil treatment, choice of clones, stand establishment, environmental optimization, harvesting, and control of production.
APPROACH: Goal orientated basic research covering abiotics, basic ecophysiology and environmental consequences of energy forestry, experimental application, covering selection and testing and stand establishment, optimizing of production enviornment, energy balance studies, input-output analysis and general synthesis, establishment of cutting production orchard and support of practical energy forestry. The EFP 1979-81 is a continuation of earlier stages 1976-78 and is planned to go on until 1986. The EFP cooperates with a number of related projects financed by the National Swedish Board for Energy Source Development (NE). The results of field experiments are intended to be 1) distributed in form of instructions to future producers: 2) submitted to energy research and development authorities for further scrutinizing and use in the planning of the national energy policy.
PROGRESS: Ten resistant high-producing domestic Salix-clones have been selected from a grand total of more than 2,500clones. About 20 new clones are subjected to systematic main tests. For testing and environmental optimization three field stations and ten field experiments (more than 40 hectares) have been established. So far five clones have responded positively enough to optimtzation measures producing 2.5-3.0 Kg DM per square meter and year (stemwood). In medium scale field experiments 1.8 kg. per square meter has been obtained. Nutrient solution has proved better than conventional mineral fertilizers if supplied in accordance with leaf area growth rate. Undisturbed stomata function seems to quantify total DM production. Work will continue.
SUPPORTED BY: Namnden for Energiproduktionforskning.

6. ENERGY FARMING

6.0001
POTENTIAL ENERGY EQUIVALENTS OF VEGETATION TYPES IN ARIZONA
Ffolliott PF, Rasmussen WO, Renewable Natural Resources Division, University of Arizona, *Tucson, Arizona, 85721,* (ARZT-0206-4168-220)
OBJECTIVE: This study will derive estimates of the energy equivalents of standing biomass in the vegetation types of Arizona; derive estimates of the energy equivalents of residues associated with current land management practices implemented in these vegetation types; and identify energy equivalents of standing biomass and management residues associated with alternative land management practices commonly implemented in the respective vegetation types.
APPROACH: Energy equivalents of standing biomass will be determined from extent of area in type, spatial densities of vegetation, rate material growth, specific gravities, and appropriate conversion values. Energy equivalents of management residues will be estimated from knowledge of volumes of residues, specific gravities, and appropriate conversion values. Three levels of biomass energy availabilities will be generated for each vegetation type: low, mean (most commonly encounted), and high.
PROGRESS: Field work and subsequent analyses have been completed to derive estimates of potential energy equivalents (in Btu's) associated with standing biomass in each vegetation type in Arizona. Similarly, determinations have been made of potential energy equivalents of residues from land management practices commonly implemented in the respective vegetation types. These results, along with other appropriate source data, are being structured to develop estimates of possible contributions of biomass to current energy needs within Arizona.
SUPPORTED BY: Arizona State Government.

6.0002
PLANT BIOCHEMISTRY
Bassham JA, Calvin M, Rapoport H, Lawrence Berkely Lab, University of California, *Berkeley, California, 94720,* (0115/4496)
OBJECTIVE: The objectives of this task are to determine photosynthetic and biosynthetic pathways in photosynthetic organisms, mechanisms of the regulation of these pathways, and bioconversion of photosynthetic products to hydrogen and methane. The goal of the research is to provide basic biochemical information which will make possible a better use of green plants in the utilization of solar energy to convert inorganic materials to useful organic substances. Such information is needed to guide genetic improvements of plants and microorganisms for greater productivity of biomass and improved quality of products: renewable chemicals, fuels, food, and fiber. Specific investigations include: elucidating metabolic pathways in green cells and locating regulatory sites, the development of methods for isolating green cells from higher plant leaves to use at test systems, plant cell tissue culture and plant regeneration as a means for genetic manipulation of desired biochemical properties, maintenance of cultured cells in a differentiated state (e.g., for photosynthesis or specific biosynthesis of useful compounds like hydrocarbon), and the manipulation of microoganisms for more efficient conversion of materials from green plants. Plant cell tissue work has been started and is now incorporated in this task.
SUPPORTED BY: U.S. Dept. of Energy, Office of Energy Research.

6.0003
HYDROCARBONS AND ENERGY FROM PLANTS
Sachs RM, Dept. of Environmental Horticulture, University of California, *Davis, California, 95616,* (CA-D#-EHT-3608-H)
OBJECTIVE: To determine the feasibility of and develop preliminary information on the technology for economic production of hydrocarbons and related materials for fuel or chemical feedstocks by means of managed farming of Euphorbias, Asclepias and Eucalyptus.
APPROACH: Periodic evaluation of yields of benzene-acetone extractable hydrocarbons as well as total caloric value under two climatic and various cultural conditions. Harvesting and process chemistry methods will also be explored. If yield data and harvesting and processing results are promising, economic analysis of cultural and harvesting costs would be undertaken.
PROGRESS: Euphorbia lathyrus seed were field planted in March; poor germination and poor seedling growth resulted in all test plots. Plantings in Oct. and Nov. were considerably better and will be used for yield vs density evaluations in '79. Plants were treated with 3, 4 dichlorophenoxyacetic acid to increase latex (acetone soluble fraction). Eucalyptus grandis plots were harvested twice in '78; yield decline of up to 50% observed in absence of additional N fertilization. Maximum yields of 10 tons dry matter/a obtained with 6-month interval between harvest dates. Caloric value of dried biomass was approx. 8000 Btu/lb. New plants of Eucalyptus are now in field plots for testing in '79. A report on hydrocarbon yields from E. lathyrus will be published in the proceedings of a conference held in Atlanta, GA in 1978.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0004
PRODUCTION OF LIPID-HYDROCARBON FUELS AND CHEMICALS FROM FRESHWATER MICROALGAE
Raymond L, Ecoenergetics Inc., *Vallejo, California, 94590,* (XB 0 9253 01)
OBJECTIVE: The objective is to design, construct, and operate a pilot plant for microalgal production, which shall be designed to test and develop processes for the production of fuels and chemicals. Tasks are: (1) to develop design criteria for a pilot algal-production system suitable for development of fuel/chemicals production processes; (2) to carry out both preliminary and detailed engineering designs of such a system, together with cost estimates; (3) to assemble, fabricate, and construct the algal production ponds and support systems (fertilizer and carbon dioxide supply, mixing, dilution, harvesting, biomass storage, etc.); (4) to operate the pond system for the purpose of testing and scaling up of microalgal biomass production systems developed at the laboratory scale by various support projects; (5) to supply sufficient algal biomass to allow development of extraction, processing, and conversion technology; and (6) to arrive at detailed, realistic economic estimates for microalgal biomass production and the cost of the fuels and chemicals derived from them.
SUPPORTED BY: U.S. Dept. of Energy.

6.0005
STUDY OF COMPARATIVE PHOTOSYNTHETIC AND FERMENTATION POTENTIALS OF CROPS FOR PLANT BIOMASS CONVERSION
Villet R, Dept. of Agricultural & Chemical Engineering, Colorado State University, *Fort Collins, Colorado, 80523,* (HB 0 9244 01)
OBJECTIVE: The objective is to carry out a field study in the central Great Plains (Akron, Colorado) on the comparative photosynthetic and fermentation potentials of 16 different herbaceous species: corn, sorghum-sudangrass, forage sorghum, pearlmillet, sunflower, Jerusalem artichoke, alfalfa, winter wheat, intermediate wheatgrass, smooth bromegrass, switchgrass, pigweed, kochia, Russian thistle, four-winged saltbush, and crested wheatgrass. The following tasks will be performed: (1) agronomic yield evaluations; (2) biochemical studies to determine cellular components in dried and ground material; and (3) enzymatic hydrolysis to assess the fermentation potential of the materials.
SUPPORTED BY: U.S. Dept. of Energy.

6.0006
RESEARCH ON CONTROL OF LIGNIFICATION IN SORGHUM
Villet R, Dept. of Agricultural & Chemical Engineering, Colorado State University, *Fort Collins, Colorado, 80523,* (HK 0 9110 01)
OBJECTIVE: The objective is to determine whether lignification can be controlled in herbaceous species. Tasks include growing sorghum plants hydroponically under tropical greenhouse conditions; assaying peroxidase activity in xylem tissue and quantitate soluble lignin precursors; analyzing lignin, cellulose and hemicellulose composition and conduct hydrolyzability assay. Results expected should be of biotechnological potential not only for cellulose conversion to fuels and chemical feedstocks but also for production of lignin precursors as chemicals.
SUPPORTED BY: U.S. Dept. of Energy.

6.0007
ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES
Green JW, Dept. of Economics, Colorado State University, *Fort Collins, Colorado, 80523,* (NRE-43-309-08-01)
OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood and home heating. Analyze the economic feasibility of energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.

APPROACH: Assess the economic resource use and environmental implications of public programs to encourage "energy farms." Develop regional reports on current land and water use, the economic implications for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregional linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empirical studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

6.0008
EVALUATION AND DEVELOPMENT OF BEET AND SORGHUM FOR HIGH BIOMASS AS FEEDSTOCK FOR ALCOHOL OR GASOHOL
Smith GA, Ruppel EG, Hecker RJ, Crops Research Lab, U.S. Dept. of Agriculture, Colorado State University, *Fort Collins, Colorado, 80523*, (5602-20090-004)
OBJECTIVE: Evaluate, identify, and develop sugar beets, fodder beets, sugar-fodder beet hybrids, and sweet sorghum with high fermentable sugar and biomass productivity, adaptability, and disease resistance for use in alcohol production and conversion to other fuels and by-products.
APPROACH: Procure fodder beet and sweet sorghum germ plasms, nationally and internationally. Synthesize fodder beet x sugar beet hybrids utilizing sugar beet breeding lines with high disease resistance. Evaluate the biomass and alcohol production potential, disease resistance and adaptability of these beet lines and hybrids and sweet sorghum.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0009
PHOTOCONVERSION
Seibert M, Solar Energy Research Inst., *Golden, Colorado, 80401*, (EG-77-C-01-4042)
OBJECTIVE: The Advanced Solar Energy Research (ASER) Program, composed of three independent research tasks, is directed to the development of new solar energy conversion and materials options. The research activities of the photoconversion task of the ASER Program are divided into the areas of photobiology, photochemistry, and photoelectrochemistry; photobiology being the subtask funded out of the DOE Biological Energy Conversion and Conservation Division of Basic Energy Science.
APPROACH: This proposal outlines a three task research program in the general area of photobiological H(2) production. Task 1 will use biochemical and genetic techniques to identify the electron transport components and pathways associated with hydrogenase activity in photosynthetic bacteria. The ultimate goal is to determine the feasibility of obtaining an organism which evolves H(2) via a hydrogenase rather than the normal nitrogenase pathway. Task 2 will focus on the purification and characterization of algal hydrogenase. This information is necessary to isolate or construct genetically an organism which will evolve H(2) via a hydrogenase rather than the norditions. Task 3 will seek to understand the properties of bacterial reaction center complexes in monolayer and multilayer stacks. These assemblies could serve as a model for or even building blocks for an in vitro H(2) evolving system.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Solar Applications.

6.0010
BIOMASS PRODUCTION AND COMPOSITION OF SUGAR CANE
Gascho GJ, Shih SF, Kidder G, Agricultural Research & Education Center, University of Florida, *Belle Glade, Florida, 33430*, (FLA-EV-01862)
OBJECTIVE: Gather sugar cane biomass production and plant composition data for use in energy farming feasibility studies: Specific objectives are: determine the biomass production, plant composition, nutrient uptake, and leaf area index with time for plants grown at 0.5 and 1.5 m spacings; relate climatic factors such as rainfall, solar radiation, and temperature to biomass and plant composition; and estimate the water requirements of sugar cane grown at the two spacings.
APPROACH: Sugar cane will be planted at 0.5 and 1.5 m row spacings. Monthly harvests will determine biomass for the row spacings. Complete nutrient non-nutrient analyses of tops, stalks and leaves will allow calculations of nutrient uptake and plant composition. Leaf area index and weather data will be regressed against yield parameters. A primary water budget will be estimated by water table, hydraulic conductivity and moisture content measurements.
PROGRESS: Dry biomass, total sugars and fiber were obtained in sugar cane and sweet sorghum experiments designed to evaluate the effects of row spacings. Narrow interrow spacings of 50 cm significantly increased dry biomass, total sugar, and fiber yields for sugar cane grown on both muck and sand soils in comparison to wider interrow spacings of 100 and 150 cm. Highest yields were 60, 26 and 31 metric tons per hectare of dry biomass, total sugars and fiber, respectively. Roma, Wray, Mer. 71-1 and Mer. 71-7 varieties of sweet sorghum were planted at row spacings of 40 and 80 cm. All varieties yielded best at the 40 cm spacing and Roma was inferior to the other varieties. Highest yields obtained in a crop planted in April were 28, 10.3 and 10.8 metric tons per hectare of dry biomass, total sugars and fiber, respectively. A replanted crop in July yielded 24 to 64% of the first planting and a ratoon crop from the April planting yielded 25 to 50% of the April planting. Leaf area index was used to estimate the biomass of sugar cane. The technique devised could be useful as a research tool and as a guide for commercial harvest scheduling. A method of sampling sugar cane grown for biomass was also devised based on the good fit of monthly stalk length increases to the log Pearson type III distribution.
SUPPORTED BY: Florida State Government.

6.0011
HARVESTING AND PLANTING SYSTEMS FOR MECHANIZING SUGAR CANE PRODUCTION FOR SUGAR OR BIOMASS
Clayton JE, Eiland BR, Sugar cane Harvest Res., U.S. Dept. of Agriculture, Agricultural Research, *Belle Glade, Florida, 33430*, (7614-20190-003)
OBJECTIVE: Develop engineering components and systems for improving the mechanical harvesting and planting of sugar cane. Develop equipment for maximizing production and reducing harvester costs for sugar cane grown as biomass.
APPROACH: Design and evaluate harvester mechanisms for adjusting cutter height and removing loose trash as stalks are cut at ground level. Design improved harvester components for topping, feeding, chopping, cleaning, and conveying sugar cane with 10% less energy than prototype harvesters now in use. Develop planting systems and harvester pickup mechanisms for narrow-row spacings likely to be used when growing sugar cane for biomass. Redesign and cushion harvester components to minimize damage and improve the cleaning of sugar cane harvested for seed. Improve mechanical planter components to reduce damage to sugar cane seed and refine sensing mechanisms for detecting skips.
PROGRESS: To determine energy for harvesting sugar cane without preharvest burning, studies of fuel consumption and time requirements for harvesting burned and unburned sugar cane were made on approximately 30 acres. The harvester required 90% more fuel per net ton to cut unburned cane than to cut burned cane. Total fuel consumption for harvesting and transport was 43% higher in unburned cane than in burned cane. Field losses during harvesting of unburned cane was 3.1 tons per acre higher than that of burned cane or about 10% of the average crop yield. Harvester output in unburned cane was only 43% of the burned cane output. Power measurements of harvester components were made in unburned and burned cane. Biomass production of sugar cane on narrow rows in ratoon cane showed no significant differences in yield with conventional rows. The variety used, CP 65-357, is probably not the best variety for yield increases by closer row spacings. Another variety planted in a narrow-row spacing showed an increase in yield of about 10 tons per acre over the conventional row yield. Mechanical planter development was continued with two field trials on 3.2 acres. The application rate was 5.12 tons per acre while conventional hand planting was 4.36 tons per acre. In another experiment the seed application rate was 4.27 tons per acre with the mechanical planter, which is a rate that would be accepted by producers.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0012
STUDY OF HYDROGEN PRODUCTION BY TROPICAL MARINE PHOTOSYNTHETIC BACTERIA FOR APPLIED SYSTEMS
Lindsey H, School of Marine & Atmospheric Sci., University of Miami, *Coral Gables, Florida, 33149*, (XR 0 8036 03)
OBJECTIVE: The objectives are: (1) to study of rate and quantum efficiencies of hydrogen production in strains of marine photosynthetic bacteria collected from tropical Atlantic region and compare them with those obtained for green and blue-green algae; (2) to examine sources of electron donors looking for renewable donors readily available in large quantities; and (3) to evaluate potential problems and benefits of bacterial system for hydrogen production as compared to algal system. Tasks include: (1) isolation of marine photosynthetic bacteria; (2) culturing of bacteria in seawater media using pure or mixed species cultures; (3) to optimize hydrogen production through environmental control (light intensity, temperature, salinity, gas mixture) of hydrogen production assays using glucose as primary electron source; (4) to initiate preliminary survey of natural substrates for bacteria growth including sargassum, sea-grass, giant kelp, mangrove leaves and blue-green algae material, that will be partially digested.
SUPPORTED BY: U.S. Dept. of Energy.

6.0013
IMPROVEMENT OF SAND PINE FOR REFORESTATION OF THE FLORIDA SANDHILLS
Rockwood DL, Agricultural Experiment Station, University of Florida, *Gainesville, Florida, 32601*, (FLA-FY-01344)
OBJECTIVE: Develop improved sand pine varieties for sandhill regeneration. Compare two breeding methods for the improvement of sand pine: Grafted seed orchard method; Seedling seed orchard method.
APPROACH: Outstanding sand pines of both the Choctawhatchee and Ocala races will be selected. Scions will be collected for establishment of separate seed orchards for the two races. With the Ocala race selections, two approaches to seed orchard development will be compared. A grafted orchard will be established as above. Open-pollinated seed from Ocala selection will be collected for establishment of a seedling orchard. Two supplemental progeny tests will be established. Utilizing data from supplemental tests, the clonal orchard and seedling orchard will be rogued. Within-family selection will also be used in the seedling orchard. Seed will be collected from both orchards to establish tests to compare gains achieved by the two methods.
PROGRESS: Age 10 growth data obtained from Chatawhatchee (C), Ocala (O), and Withlacoochee (W) sources established at 4 locations in Florida indicate that C had the best survival and O had the biggest trees at all locations while W was generally intermediate for survival and growth. O's plot volume production exceeded the other sources in East Florida whereas C gave greater volume production in West Florida. C and W density at one location was some 7% greater than O's. From all sources, 197 selected superior trees provided material for the establishment of 16 seedling on clonal orchards, sufficient to supply the bulk seed needed for this species. Two comparative plantings were established with progenies derived from clonal and seedling orchards of the same O ortets. For initial survival and early growth, both types of orchards gave similar results. Better performing C progenies will be evaluated for biomass and energy production, for pulpwood production,

and for sandhills reforestation in South Carolina. Assessments of C progenies suggest high variation in wood density and tree size and little genetic variation in energy yield per weight unit. Research during the project life has resulted in the attainment of genetically improved sand pine seed. Specific accomplishments include: identification of significant variation between-and wintin-sources and selection of superior trees.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0014
BIOMASS PRODUCTION AND COMPOSITION OF SUGAR CANE
Mishoe JW, Dept. of Agricultural Engineering, University of Florida, *Gainesville, Florida, 32601*, (FLA-AG-01862)
OBJECTIVE: The overall objective is to gather sugar cane biomass production and plant composition data for use in energy farming feasibility studies. Specific objectives are: determine the biomass production plant composition, nutrient uptake, and leaf are index with time for plants grown at 0.5 and 1.5 m spacings; relate climatic factors such as rainfall, solar radiation, and temperature to biomass and plant composition; and estimate the water requirements of sugar cane grown at the two spacings.
APPROACH: Sugar cane will be planted at 0.5 and 1.5 m row spacings. Monthly harvest will determine biomass for the row spacings. Complete nutrient and non-nutrient analysis of tops, stalks, and leaves will allow calculations of nutrient uptake and plant composition. Leaf area index and weather data will be regressed against yield parameters. A primary water budget will be estimated by water table, hydraulic conductivity and moisture content measurements. A sugar cane growth model will be developed.
SUPPORTED BY: Florida State Government.

6.0015
INTEGRATED MANAGEMENT SYSTEMS FOR AQUATIC PLANTS
Mace AC, Buckingham GR, School of Forest Resources & Conservation, University of Florida, *Gainesville, Florida, 32601*, (7007-20280-002-A)
OBJECTIVE: Determine the most effective integrated systems for managing undesirable aquatic plant species, based on new and improved understanding of life cycles, ecological requirements, effects of other flora and fauna, and responses to herbicides and growth regulators and utilization of biomass.
APPROACH: Observe, measure, and evaluate aquatic plant responses to light, temperature, nutrients, soil substrate, water quality, and other selected factors. Establish interrelationships of aquatic plants, phytoplankton, and periphyton to determine the effects on plant growth. Evaluate the effect of water quality on biomass productivity and the feasibility of producing energy from the excessive biomass of the undesirable plants. Conduct tests in the laboratory, greenhouse, and field to evaluate effects of aquatic herbicides and growth regulators on aquatic flora and fauna. Using information obtained, evaluate different combinations of biological, chemical, and cultural measures to identify most effective integrated management systems.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0016
ENERGY AND CHEMICALS FROM WOODY SPECIES IN FLORIDA
Rockwood DL, Conde LF, School of Forest Resources & Conservation, University of Florida, *Gainesville, Florida, 32601*, (FLA-FY-01924)
OBJECTIVE: Proposed work is aimed at assessing the potential for sustained production of biomass by species of Pinus, Eucalyptus, and Melaleuca in Florida. Land availability and productivity will be assessed to focus field experiments on the most suitable sites.
APPROACH: Field trials will be designed to evaluate effects of site preparation, fertilization, and cropping components of cultural treatments. Site effects of biomass-farming on water use and nutrient conservation will be evaluated. Results will also include evaluation or rotation age and energy input/output efficiencies.
PROGRESS: A land availability survey for Florida was conducted to determine the extent to which biomass forms of the candidate species could be established. Suitable acreages appear to be available for all species. Preliminary biomass production assessments and energy yield determinations for individual trees have been completed for all species. Per unit area biomass yield figures have been obtained from existing "biomass" stands of sand pine, slash pine, and melaleuca; yields of melaleuca and sand pine are very acceptable. Use of selected slash pine will result in acceptable yields for that species. Biomass plantations of Eucalyptus grandis, E. viminalis, Australian pine, and melaleuca have been established, and plantings of sand pine and slash pine are underway. These studies will evaluate cultural practices, spacing influences, genetic variability for biomass production, biomass production levels over time, and effects on water yield and properties. The E. grandis, Australian pine, and melaleuca plantings are located near Labelle, Florida, the E. viminalis test is near Gainesville, the sand pine plantings are at Clarksville, Perry, and Eureka, and the slash pine trials are at Gainesville, Trenton, and Perry.
SUPPORTED BY: Florida State Government.

6.0017
VARIATION IN BREEDING POPULATIONS OF SOUTHERN PINES
Rockwood DL, Goddard RE, School of Forest Resources & Conservation, University of Florida, *Gainesville, Florida, 32601*, (FLA-FY-01811)
OBJECTIVE: Evaluate changes during the life cycle in genetic variation for growth and pest resistance. Document genotype environment interactions, and evaluate any changes during the life cycle, for growth and pest resistance. Develop procedures for genotypic evaluation of phenotypic selection. Develop procedures for maximization of genetic gain.
APPROACH: The project objectives will be met largely by the analysis of numerous existing and to-be-established progeny tests, field plantings of seedlings derived from superior trees. A portion of the effort will involve the selection of additional superior trees in natural forest stands and plantations. The activities will be conducted in Florida, Georgia, Alabama, and Mississippi and will be completed in approximately five years.
PROGRESS: Analyses of 76 slash pine property tests located in the Southeast were completed. Eight tests were more than 10 years old, 27 were 6 to 10 years of age, and 43 were 5 years old or less. These tests and others were segregated into open-pollinated and control-pollinated categories and formed the basis for clonal evaluations. C. Clonal evaluations were found to differ depending on the type and age of progenies. Control-pollinated progenies show strong specific combination effects and were often deviant from open-pollinated progenies. Older progency tests tended to exaggerate the differential of progenies relative to commercial checks. Fifty progenies of good growing clones unselected for pitch canker resistance were outplanted at two epidemic locations and also artifically inoculated. Progenies and grafts of 11 selected trees were also outplanted and inoculated. Slash pine progenies which had done well in "biomass" plantings were evaluated for energy yield, and 37 will be established in energy plantations. Energy yields may be more than doubled by use of progenies that survive well, have high wood density and extractives, and grow well at close spacings. Progency tests of some 300 longleaf pine, to be converted to seedling seed orchards, were established at 12 locations in the Southeastern coastal plain. Seeds were obtained from more than 250 new selections in preparation for expanding the orchards in 1980.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0018
SILVICULTURE AND TREE IMPROVEMENT OF EUCALYPTUS IN FLORIDA (EUCALYPTS IN FLORIDA)
Geary TF, Meskimen GF, Southeastern Forest Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Lehigh Acres, Florida, 33936*, (SE-1113)
OBJECTIVE: Develop technology for the commercial culture of eucalypts in Florida.
APPROACH: Development of a procedure to single seed nursery containers will be attempted to reduce nursery costs and improve mechanization. Success will depend on finding techniques to clean and pellet eucalypt seeds. Seeds for plantations will come from tree strains to be bred specially for south Florida. Methods must be developed to vegetatively propagate seed trees of the superior strains, and for improving seed production and harvesting. Growth of different strains on several soil groups following varying site preparation techniques will be measured to determine the most productive combinations. To increase productivity, new fertilizer prescriptions will be tested, as well as new methods to control weeds on old fields.
PROGRESS: Initiated work on techniques to mass propagate superior eucalyptus trees by rooting cuttings in order to fully utilize genetic superiority. Analyzed progeny test data for genetic variation in coppicing ability within and among Eucalyptus spp. in order to develop strains of encalypts that coppice reliably. The basal canker fungus, Diaporthe cubensis, infects many trees of Eucalyptus grandis in south Florida. Damage to trees is minor, but the fungus might be a cause of stumps failing to coppice. Stumps of E. grandis contain an adequate number of dormant buds that are needed for coppicing, so failure of stumps to coppice is not due to lack of buds. Eucalyptus and Melaleuca have a great potential as fuelwood crops for south Florida. A factor limiting development of this alternative energy source is the lack of equipment that can burn wood. Pyrolysis efficiently converts wood into charcoal, oil, and gas that can be burned by existing equipment.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

6.0019
METHANE PRODUCTION FROM AQUATIC PLANTS AND VEGETABLE CROP RESIDUE
Reddy KR, Graetz DA, Campbell KL, Agricultural Research & Education Center, University of Florida, *Sanford, Florida, 32771*, (FLA-CF-02028)
OBJECTIVE: Optimize the production of aquatic plant biomass while maximizing the nutrient removal from waste waters, develop techniques for processing of aquatic plants and evaluate potential availability of vegetable crop residues and produce methane from aquatic plants and vegetable crop residues.
APPROACH: Controlled greenhouse experiments will be conducted to determine the nutrients limiting the growth of aquatic plants (water hyacinth, pennywort, cattails, and elodea). In the field studies limiting nutrients will be added to maximize the biomass production, while increasing the efficiency of nutrient removal. A survey will be conducted to determine the potential availability of vegetable crop residues for methane production. Techniques for mechanical preprocessing of aquatic plants for digestion will be developed. Various combinations of aquatic plants and vegetable crop residues will be digested to maximize the methane production.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0020
EFFECTS OF SPACING AND COPPICE CYCLE ON WOOD QUALITY OF SHORT-ROTATION HARDWOODS
Beckwith JR, Agricultural Experiment Station, University of Georgia, *Athens, Georgia, 30602*, (GEO-0025-MS-C)
OBJECTIVE: Study the effects of spacing and length of coppice rotations on wood quality with emphasis on wood density within and among selected clones.
APPROACH: Nine clones of various age sycamore spaced in plantations at 1' x 2', 2'x 4', and 4' x 4' are being harvested at 1, 2, 3 and 5 years intervals (in replicated blocks). The wood density in these trees will be examined as well as fiber proportion and dimensions. Then these basic wood characteristics will be related to the silvicultural control under which they developed in order to determine best practices for producing various wood quality.

PROGRESS: Experimental plots of 3-year-old sweetgum short-rotation-hardwoods on 11-year-old rootstocks have been subjected to various combinations of irrigation and low-level extended photoperiod. The treatment effects on specific gravity were examined, and it was found that irrigation produced a small but statistically significant reduction in wood density. The effect of extended day-length was not statistically significant, although an indication of some slight reduction in specific gravity by such treatment was found. An examination of cell proportions (rays, fibers, and vessels) in short rotation sweetgum is in progress now to determine how such cell proportions are related to wood density, and to determine the extent of genetic control of them.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0021
APPLICATION OF TISSUE CULTURE TECHNIQUES TO SCREENING AND CLONING OF SUPERIOR HARDWOOD GENOTYPES
Brown CL, Agricultural Experiment Station, University of Georgia, *Athens*, *Georgia*, *30602*, (GEO-0025-MS-B)
OBJECTIVE: Develop laboratory screening techniques to assay for inherent vigor at an early age among selected hardwood genotypes, and develop techniques for optimizing plantlet formation (cloning) of putative superior genotypes for subsequent field testing.
APPROACH: Cambial cultures will be established on defined media from sycamore, sweetgum, alder, and possibly other hardwoods showing promise of enhanced biomas production from field selections of putative high and low vigor clones under the same aged material (same internode) of stump sprouts growing under relatively uniform conditions. Observations on initial rates of cell proliferation and sustained growth of cells (increase in cell numbers) will be made under rigidly controlled laboratory conditions (light, temperature, photoperiod, etc.). Laboratory screening of inital and subsequent growth of cells will be correlated with the inherent vigor of the initial field selections. Attempts will be made to clone each selection (i.e., produce plantlets and young containerized seedlings from each clone in culture) then transplant these to the field for subsequent testing for vigor. These procedures will hopefully result in being able to select for inherent vigor at an early age.
PROGRESS: The application of high intensity, short rotation coppice forestry for maximum yields of wood for fiber, energy, and chemical feedstock will require large quantities of superior planting stock either as seedlings or clonal lines of selected genotypes. In the Southeastern U.S. the most promising species for this type management include sweetgum (Liquidambar styraciflua) and sycamore (Platanus occidentalis) which may be interplanted with nitrogen fixing species such as black locust (Robinia pseudoacacia) or alder (Alnus spp.) to reduce energy inputs from fertilization at each harvest or cutting cycle. We are continuing to investigate the possibility of cloning these species in tissue culture either by plantlet formation or embryogenesis. On several different media buds and shoots have been produced in cultures of sweetgum and black locust. Adventitious shoots are easily rooted, and plantlets of some species have been outplanted for field observations. A more efficient method of propagation in tissue culture is by somatic embryogenesis. With embryogenesis the young embryoids are handled as normal embryos and can be transferred to nutrient media.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0022
HARDWOOD SHORT ROTATION CROPPING
Steinbeck KL, *Brown CL*, Agricultural Experiment Station, University of Georgia, *Athens*, *Georgia*, *30602*, (GEO-0025-MS-E)
OBJECTIVE: Continue researching the yields of above- and below-ground biomass of selected hardwoods grown convarious sites at different spacings and coppice cycles under an intensive system of short-rotation management. Study some of the physiological parameters of carbohydrate production, mineral nutrition, and reserve food accumulation in coppiced root systems and the mobilization of this reserve into new sprout growth.
APPROACH: Replicated, randomized block designs. Regression and covariance analyses for some growth and yield studies. Soil and plant tissue analysis will generally include gravimetric and chemical analyses. Height, diameter, weight, photosynthetic and transpirational measurements in field and laboratory. Chemical and physical analysis in the laboratory.
PROGRESS: Caloric values for young sprouts of nine hardwood species (Acer rubrum, Acer negundo, Fraxinus pennsylvanica, Liquidambar styraciflua, Liriodendron tulipifera, Platanus occidentalis, Prunus serotina and Quercus nigra) were determined. The sprouts varied between 6 and 15 years of age and were collected in May and July. Energy values for wood, bark, first order branches, twigs and leaves were determined with a bomb calorimeter. Caloric values for this coppice material averaged 4791 cal/g and are comparable to published values for older wood. The differences among species were small. Monitoring (height and diameter growth, survival, soil nutrients) of the hardwood plantations (Platanus occidentalis, Liquidambar styraciflua, Robinia pseudoacacia, Alnus glutinosa) established in 1977 and 1978 continues. The field phase of an experiment to determine the effects of irrigation and interruption of the dark period on the growth of sycamore and sweetgum coppice is completed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0023
BIOMASS FROM SHORT-ROTATION FOREST TREES
Steinbeck KL, *Brown CL*, School of Forest Resources, University of Georgia, *Athens*, *Georgia*, *30601*, (EG-77-S-09-1015)
OBJECTIVE: Design experiments to evaluate the biomass production of sycamore, sweetgum, and European black alder in two 50 acre plantations, one each in the Piedmont and Coastal Plain of Georgia. Fertilization and irrigation responses will be tested along with monitoring tree growth and soil nutrient status. Establish direct energy input-output balance based on biomass yields. Develop cloning techniques for screening and testing superior phenotypes under laboratory and field conditions; following testing, plus genotypes will be identified for future production stock. Trees are to be initially harvested at 3 years then coppiced at 3 to 6 year intervals, and above ground biomass (excluding foliage) yield determined. Foliage will be recycled each year.
SUPPORTED BY: U.S. Dept. of Energy.

6.0024
EVALUATION OF NEW CROPS FOR HYDROCARBON AND OIL PRODUCTION
Adamson WC, Georgia Agricultural Experiment Station, U.S. Dept. of Agriculture, Agricultural Research, *Experiment*, *Georgia*, *30212*, (7707-20160-004)
OBJECTIVE: To evaluate productivity of new energy producing crop plants. To select species and lines that are most promising. To evaluate environmental factors influencing their productivity.
APPROACH: Grow large numbers of plants of different seed lots of selected species in replicated tests with individual plants as plots. Extract dried ground plant samples with acetone followed by Cyclohexane. Recover the solvent and weigh the dry extracts. The acetone exiract will comprise a rough measure of oil and polyphenol yield while the cyclohexane extract will be primarily hydrocarbons. Based upon these tests, select the best species and lines for further tests. The further tests will have variables such as fertility, harvest date, harvest methods or other environmental variables suggested by the completed work. Various species will be selected from the following plant groups based on index ratings of plant species by the Northern Regional Research Center, SEA-AR, Peoria, Illinois: Compositae, Graminae, Asclepiadaceae, Euphorbiaceae, Caprifoliaceae, Labiatae.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0025
OTEC-AQUACULTURE MACROALGAE EXPERIMENTS
Helfrich P, Hawaii Inst. of Marine Biology, University of Hawaii, *Honolulu*, *Hawaii*, *96822*, (A/R-13)
OBJECTIVES: 1. To determine the biological feasibility of culturing selected algal species in OTEC effluent. 2. To determine optimal environmental parameters for the growth of the test algae in an OTEC-aquaculture system. 3. To test grow-out of the algae if smaller-scale experiments are promising. Seaweeds may be used for food, animal feed, industrial and pharmaceutical chemicals, and biomass for energy conversion. OTEC-aquaculture, if feasible, provides a means for large-scale intensive seaweed culture using "free" water flows, temperature control, and increased nutrient concentrations.
SUPPORTED BY: U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin.

6.0026
FUELWOOD PRODUCTIVITY OF FAST-GROWING SUBTROPICAL TREE LEGUMES
Brewbaker JL, *Rotar PP*, Dept. of Horticulture, University of Hawaii, *Honolulu*, *Hawaii*, *96822*, (HAW00802-G)
OBJECTIVE: Determine growth rates, fuelwood properties, leaf meal yields, and site specificities of giant leucaenas under diverse population densities. Determine growth rates and N-fixation capabilities of fast-growing tropical leguminous tree (TLT), and assess their suitability as plantation fuelwoods. Establish seed collections, seed orchards and data banks on site adapatability and performance of fast-growing fuelwood TLT.
APPROACH: Varietal and population density trials of L. leucocephala and related species will be conducted. Seventeen fast-growing tropical leguminous trees will be collected for nursery and field establishment studies. Germ plasm collection for Hawaii Foundation Seed Facility; seed orchard establishment for outstanding fuelwood cultivars; data banks on properties of TLT.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0027
GENETICS AND AGRISILVICULTURAL STUDIES OF TROPICAL WOODY LEGUMES
Brewbaker JL, *Tamimi YN*, Dept. of Horticulture, University of Hawaii, *Honolulu*, *Hawaii*, *96822*, (HAW00803)
OBJECTIVE: Identify Leucaena strains with high fuel and wood productivity. Breed Leucaenas with high forage and N-fertilizer yields and low mimosine contents. Identify Acacia cultivars with superior agrisilvicultural properties. Assemble and evaluate germ plasm of Mimosaceous legumes with promise as fuel or N sources in tropics.
APPROACH: Yield trials with variety, density, management, and environment as variables. Breeding and genetic studies of leucaena species, varieties, and their progenies. Yield trials of Acacia koa and other acacias suitable for forest product and recreational use in Hawaii. Seed and cultivar collection, introduction, and evaluation in Hawaii for fuel and forage or nitrogen productivity.
PROGRESS: A germ plasm bank was established of seeds of the Hawaiian Acacia species A. koa and A Koia. A reputed third species, A. kauaiensis, could not be verified. Collections were made from all major islands and all major natural populations were designated. The breeding system of A. koa was determined to be primarily by cross-pollination, due to a dichogamy of several days between male and female parts of the same flower, and a high synchrony of the flowers on a tree. There was no self-incompatibility. Seed production was reduced significantly by rains and low insect populations at flowering time in the spring and by seed weevils. Koa was shown to be of two major bole types that appear to be distinct genetically, the predominant form a low-branching wide-crowned tree. Only on the island of Hawaii were there large populations of an erect, tall form that branched sparsely. Genetic variations in leaf and pod type and in peroxidase isoenzymes were described, and studies conducted of seed germination, and of nodulation and soil management for seedling establishment.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0028
TIMBER AND WATERSHED MANAGEMENT IN HAWAII
Skolmen RG, Walters GA, King JP, Pacific Southwest Forest & Range Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Honolulu, Hawaii, 96813*, (PSW-1251)
OBJECTIVE: Develop and extend scientific knowledge needed to manage native and exotic species to enhance the timber resource base and protect and improve watersheds in Hawaii.
APPROACH: Field trials and laboratory tests will be made of species adaptability, silvicultural techniques, intensive cultivation and tree planting, and superior progeny for selected native and exotic trees. Container nursery procedures will be developed. Hydrologic properties of soils and forest influences on water quality and quantity yield will be evaluated by field and laboratory tests.
PROGRESS: Provenance tests of Eucalyptus saligna and E. grandis were installed to seek genetically improved trees for forestation and to select provenances resistant to the eucalypt canker disease, Diaporthe cubensis. Growth measurements of unmanaged coppice stands of Eucalyptus globulus indicated that yields from coppice in 70-year-old stands are much lower than predicted. The Hawaii Division of Forestry is constructing a new container tree nursery based on designs resulting from research on nursery systems for Hawaii s tree species. Spacing, fertilizer, and mixed eucalypt-legume trials were established in cooperation with C. Brewer and Company to begin studies of intensive culture of eucalypts for biomass using E. saligna, E. grandis, Albizia falcataria, and Acacia melanoxylon. A complete storage and retrieval program was developed to sort and analyze voluminous soil profile and laboratory data collected in conjunction with a study of the hydrologic properties of soils under declining ohia forests.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

6.0029
SOIL FERTILITY PRACTICES FOR SUSTAINED HIGH CROP QUALITY AND YIELD RESOURCE CONSERVATION
Mayland HF, Carter JN, Leggett GE, Snake River Conservation Research Center, U.S. Dept. of Agriculture, Agricultural Research, *Twin Falls, Idaho, 83341*, (5818-20780-004)
OBJECTIVE: Characterize the soil chemical reactions that reduce availability of fertilizer Zn and P to crops. Determine N partitioning in Phaseolus vulgaris at different growth stages of cultivars having a relatively high or low symbiotic N(2)-fixation ability. Evaluate fertility and irrigation requirements of Beta vulgaris subspecies which could serve as substrates for alcohol production. Field test the potato growth model to predict daily N fertilizer requirements.
APPROACH: Since availability to Phaseolus vulgaris will be determined in pot tests using synthetic Zn fertilizer to unavailable forms will be evaluated in a 4 year incubation study during which extractable P will be determined on subsamples. Nitrogen partitioning in Phaseolus vulgaris will be determined by frequent sampling and analysis of plant material grown in the growth chamber or field and fertilized with N or N sources. Fermentable sugar concentration and yield of sugar and fodder beets will be determined in field studies where these crops are grown under 2 N and 2 water-stress levels.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0030
THE UTILIZATION OF TWO-YEAR SHORT-ROTATION DECIDUOUS BIOMASS FOR ENERGY, PARTICLEBOARD AND CHEMICALS
Chow P, Rolfe GL, Halland II, Dept. of Forestry, University of Illinois, *Urbana, Illinois, 61801*, (ILLU-55-0304)
OBJECTIVE: Develop efficient ways to use solar. renewable woody biomass grown under intensive silvicultural techniques as substitutes for non-renewable fossil fuels through gasification and combustion. Evaluate the feasibility of converting high-yield plantation-grown wood to paper and particleboard so as to stretch future wood supplies. Determine the chemical composition (acidicity, extractive content, cellulose, lignin, and pentosan content) and physical properties of seven biomass plantation species. Determine the potential economic value of various products made from high-yield woody biomass.
APPROACH: A 7 x 2 x 2 factorial design involving 7 species (autumn olive, black alder, black locust, E cottonwood, royal paulownia, silver maple, and sycamore), 2 sites (bottomland and upland), and 2 regeneration techniques (seedling and coppicing) will find the effects of species, site, and regeneration techniques on the fuel values, paper and board properties, and chemicals made from 2-year old juvenile wood. The experiment is divided into five phases.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0031
SOLAR ENERGY CONVERSION THROUGH WOODY BIOMASS PRODUCTION
Rolfe GL, Arnold LE, Zimmerman R, Dept. of Forestry, University of Illinois, *Urbana, Illinois, 61801*, (ILLU-55-0342)
OBJECTIVE: Develop a net energy balance for energy plantations. Determine relationships between four woody species and biomass yield. Determine the optimum spacing and cutting cycle for these species. Determine the nutrient requirements and best method of supplying these nutrients for sustained biomass yield. Develop site selection criteria in order to determine those marginal lands best suited for energy production.
APPROACH: A series of field test plots will be established on a range of sites in central and southern Illinois to evaluate the potential of various species for maximum biomass production for energy conversion. Nutrient requirements will also be determined through tissue and soil analysis during the growth period. Energy yields will be measured and a net energy balance developed.
PROGRESS: Evaluation of pilot study woody biomass plots planted in May 1978 resulted in essentially three conclusions: 1) Relatively intensive site preparation is required for first year establishment of biomass plantings under the narrow spacing-short rotation scenario; 2) Economically and energetically sound methods of weed control are needed before successful establishment of an energy crop can occur; 3) Supplemental moisture must be applied for first year establishment of seedlings and very likely during successive growing seasons. Intensive site preparation (moldboard plowing, discing) is suited to level to gently sloping sites. Similar techniques must be refined before they can be utilized on moderate to steep slopes in order to minimize erosion. Ultimately, site preparation techniques must be defined to meet site quality impact limitations as well as management objectives. Weed control is imperative when rapid establishment and first year production of woody species are important. Herbicides offer one energetically sound alternative for weed control. Certain urea compounds have been found to provide good weed control in sycamore and autumn olive without substantially inhibiting establishment and first year production of the energy crop. These compounds and others are under continued study.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0032
INTENSIVE CULTURAL PRACTICES FOR HARDWOOD TREE ESTABLISHMENT AND EARLY GROWTH.
Geyer WA, Agricultural Experiment Station, Kansas State University, *Manhattan, Kansas, 66502*, (KAN-00168)
OBJECTIVE: To develop techniques for hardwood tree establishment in the Plains through: selection of safe herbicides for weed control in direct seeding and bareroot seedling transplants; evaluation of herbicide effectiveness for grass and broadleaf weed control; and development of management schemes for direct seeding through field tests of weed control, fertilization, and spacing.
APPROACH: Greenhouse pot studies and field testing of herbicide effects on large seeded tree species will be evaluated for germination, early seedling growth, and development. Several herbicides will be screened for toxicity to new seedling transplants, established plantings, and new coppice sprouts. Previously established biomass plantations will be measured for growth.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0033
GREAT PLAINS ENERGY FOREST STUDY
Geyer WA, Dept. of Forestry, Kansas State University, *Manhattan, Kansas, 66502*, (KAN-05-620)
OBJECTIVE: Develop a short rotation silviculture system to produce fuel wood from woody biomass. Determine productivity of coppicing hardwood trees, determine financial and energy costs, and evaluate effectiveness of herbicides for weed control.
APPROACH: Establish study plots using "Nelder" circular design to test species, spacing, and weed control difference in productivity.
SUPPORTED BY: Kansas State Government.

6.0034
SUGAR CANE AND SWEET SORGHUM AS A RENEWABLE BIOMASS ENERGY RESOURCE
Cochran BJ, Ricaud R, Dept. of Agricultural Engineering, Louisiana State University, *Baton Rouge, Louisiana, 70803*, (LAB02011)
OBJECTIVE: Determine the effects of spacing and row profiles on the biomass yield of plant and ratoon sugar cane and sweet sorghum. Study the yield components and other factors affecting yields of plant and ratoon sugar cane during various stages of plant growth. Evaluate methods of mechanically harvesting sugar cane and sweet sorghum grown from the planting and production treatments of Objective 1. Study commercial mechanical systems available for harvesting maximum sugar cane biomass in the sugar cane production areas of the United States.
APPROACH: The research will be conducted at the St. Gabriel station. Studies involving sugar cane will be made to determine effect of type and width of planting farrows on growth, yield, and harvestability of sugar cane from plant cane of ratoon crops. Plant population will be varied by conventional planting methods and single drill and multiple drill with different spacing and planting rates. A similar plan will be used with sweet sorghum. Planting methods, equipment for covering, harvesting means will be evaluated. Biomass data will be collected.
PROGRESS: The biomass yields produced at each stage of maturity and plant heights were generally lowest with Wray, intermediate with Mer. 71-1 and highest with Mn. 1500. The yields and plant heights increased from the boot stage to the soft dough stage. The total fermentable sugar yields at the flowering stage were highest with Mn. 1500 and lowest with Mer. 71-1. The sugar yields at the soft dough stage with Wray were similar to Mer. 71-1 and lower than with Mn. 1500. The biomass and sugar yields of each variety at each stage of maturity generally increased with each successive increase in the number of drills and plant populations. However, since the stalk diameter decreased with increasing plant populations, the relationship between yield and plant population was not linear. Also, the smaller diameter of stalks increased lodging. The preliminary results indicated that the optimum planting method in the Louisiana sugarcane area is two drills on 180-cm rows with a plant population of approximately 100,000plants per ha. A modified soldier harvester was satisfactory for harvesting all methods of planting.
SUPPORTED BY: Louisiana State Government.

6.0035
SELECTION OF IMPROVED VARIETIES OF SUGAR CANE FOR LOUISIANA
Breaux RD, Fanguy HP, Sugar cane Field Lab., U.S. Dept. of Agriculture, Agricultural Research, *Houma, Louisiana, 70360*, (7412-20090-006)
OBJECTIVE: Develop sugar cane varieties improved in yield up to 75 tons/ha under present cultural conditions and up to 125 to 185 tons/ha for biomass and/or narrow row spacings that resist strain H and I of sugar cane mosaic and ratoon stunting disease; resist sugar cane borer attacks to the extent that not more than one insecticide ap-

plication is required; tolerate freezes of - 4 degrees C; and harvest well by old or new harvesting methods.
APPROACH: Annually conduct selection program among 65,000commercial seedlings and 35,000basic single stools. Evaluate selected clones in line trial, infield and outfield replicated tests in cooperation with pathologists, entomologists, and physiologists. Cooperate with SAES and American Sugar Cane League in increase and release of new varieties. Conduct inheritance studies on yield components in seedling progenies and backcross generations of basic material to develop new selection techniques and breeding methods.
PROGRESS: CP 65-357 has expanded to 61% of the state acrage. Two varieties released in 1978, CP 70-321 and CP 70-330, were expanded to the limit of the seed supply. Rapid acceptance of these high sucrose varieties again contributed to a record production of 100 kg of sugar per metric ton of cane for the second straight year in 1979. Progress in improvement in cane yield is not so spectacular, however, CP 72-355 and CP 72-356 significantly outyielded CP 65-357 in tonnage in second stubble outfield tests. Fifty varieties were assigned new '79 numbers in 1979. A higher degree of mosaic resistance has apparently been transmitted to high yielding experimental varieties of the '73-'78 series from L 65-69 and S. spontaneum US 56-15-8. A replicated test identified several superior early generation S. spontaneum hybrids for biomass production.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0036
HYBRIDIZATION SACCHARUM SPECIES AND RELATED GENERA
Dunckelman PH, Sugar cane Field Lab., U.S. Dept. of Agriculture, Agricultural Research, *Houma, Louisiana, 70360,* (7412-20090-007)
OBJECTIVE: Enlarge the genetic base in Saccharum by incorporating into commercial breeding lines new germ plasm having characters for high cane tonnage, up to 75 tons/ha using conventional cultural practices and up to 185 tons/ha for biomass and narrow row plantings; stubbling ability for up to 5 to 6 years; mosaic and ratoon stunting disease resistance (near immunity); and freeze resistance to -6 degrees C.
APPROACH: Hybridize selected germ plasm from the World Collection of Sugar Cane and related grasses. Backcross or intercross selected clones. Select progeny for desired characters. Synchronize and promote flowering of divergent species in order to make crosses by control of temperature, photoperiod, and other environmental/cultural conditions.
PROGRESS: Ninety-five intergeneric and biparental sugar cane crosses were made between commercial breeding lines and selections from new breeding lines including Saccharum spontaneum, S. robustum, Sclerostachya, Ripidium and Erianthus. These new breeding lines are noted for their disease resistance, pest resistance, cold tolerance, vigor and/or ratooning ability. Over 50% of the more recent commercial selections of the 1978 and 1979 CP series have one or more of these basic breeding lines in their pedigree. Over 240,000viable seed were produced. Further, over 7.000 viable seed were produced in 1979 where either Ripidium bengalensium or R. elephantinum were used as the non-recurrent parents and the commercial breeding canes (CP and L varieties) were used as recurrent parents. Both Ripidium species are noted for their tremendous vigor. Accordingly, progenies of these crosses will be screened for potential to produce biomass.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0037
SUGAR CANE QUALITY AS AFFECTED BY ENVIRONMENT, VARIETIES, OR MANAGERIAL PRACTICES
Irvine JE, Sugar cane Field Lab., U.S. Dept. of Agriculture, Agricultural Research, *Houma, Louisiana, 70360,* (7412-20090-009)
OBJECTIVE: Determine effect of environment, variety, and farm practices on mineral and major organic constituents, energy content, and extraneous matter.
APPROACH: Measure the major inorganic and organic constituents as affected by season, freezing, variety, sprays, and other factors. Determine energy content of biomass sugar cane under different cultural regimes and the effect of extraneous matter on constituents and energy content.
PROGRESS: A sodium salt of glyphosate was applied aerially as a ripening agent at 34 locations to study variety response, rate response and effect of length of time between application and harvest. A significant increase in sugar per acre was obtained for varieties CP 48-103, CP 61-37, CP 65-357 and CP 70-330, but not for NCo 310, L 62-96 or CP 67-412. No difference in response was detected between application rates of 0.2, 0.3 or 0.4 lb ai/a. The data suggested that the interval between application and harvest could be reduced from 5 to 7 weeks to 3 to 5 weeks. Periodic sampling of a replicated variety test following a freeze produced data indicating distinct varietal differences in quality parameters. The varieties NCo 310, CP 70-321 and CP 72-356 were superior in keeping qualities. While the varieties L 65-69 and CP 70-330 were unacceptable for sugar manufacture 36 days after freezing and all varieties were unacceptable after 72 days, only the variety CP 70-330 was low in fermentable solids, indicating that most of the varieties tested would be acceptable for alcohol production long after being unfit for sugar production.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0038
SWEET SORGHUM DISEASES: ETIOLOGY AND CONTROL THROUGH BREEDING FOR DISEASE RESISTANCE
Gillaspie AG, Beltsville Agricultural Research Center, U.S. Dept. of Agriculture, Agricultural Research. *Beltsville, Maryland, 20705,* (1110-20090-002)
OBJECTIVE: Develop sweet sorghum varieties with high fiber (for biomass), with high sugar, and with low sugar (for syrup), with resistance to disease and cold damage, and adapated to efficient production methods. Measure the influence of pathological factors on yield.
APPROACH: Make crosses of sweet sorghum lines to obtain seed for the USDA variety testing program. Virus strain identification and separation methods and diagnostic methods are determined.
PROGRESS: Fifty-five successful crosses of sweet sorghum were completed in Beltsville for production of F(1) seeds for field evaluation of biomass potential in Mississippi. Data (F(2)) from sorghum crosses in which one of the parents was infected with sugarcane mosaic virus (SCMV) was compared with progenies from crosses in which both parents were healthy. The primary genetic effect of the virus is an increase in deviation of the dihybrid populations from expected ratios. These deviations were greatest when the double-recessive parent was infected. Polysaccharides from yeast cell walls and from Bacillus subtilis and Streptococcus pneumoniae type III cell-free culture liquids inhibited SCMV-infection of sorghum by 90-110%.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0039
CLASSIFICATION, PROPERTIES AND UTILIZATION OF MINNESOTA ORGANIC SOILS
Farnham RS, Dept. of Soil Science, University of Minnesota, *St. Paul, Minnesota, 55101,* (MIN-25-017)
OBJECTIVE: Characterize the properties of organic soils, to classify and survey them, and evaluate their potential for agriculture, as an energy source and for waste treatment.
APPROACH: Laboratory and field studies including peat surveys and studies to aid development of organic soils for crop production, energy and waste treatment, hydrologic and water quality studies of peatland environments to be made.
PROGRESS: The Anoka peatland project concerning research on organic soils was expanded to include vegetable crop variety trials and demonstration plots, minor element needs on organic soils, and the establishment of a woody biomass plant nursery for propagation of energy crops on peatlands. The final report of a two-year study entitled "Agricultural Reclamation of Minnesota Peatlands" was completed and submitted to the State of Minn. Dept. of Natural Resources peat program. Assistance with classification of organic soils was provided for several State and Federal agencies. These included D.N.R. of Minnesota, Alaska, Maine, South Carolina, and Michigan as well as USDA Soil Conservation Service, U.S. Geological Survey, U.S. Bureau of Mines, and the U.S. Dept. of Energy. Analyses of organic soils were made for energy values, major and minor element contents, physical properties and properties useful for their classification. In September I attended an Int. Peat Society Symposium in Finland on "Classification of Peat" and an International Energy Agency seminar in Sweden and Finland concerned with plant biomass for energy. Was appointed a Vice President of the International Peat Society in September. Final plans have been made for the Int. Peat Societies Congress to be held in Duluth in Aug. 1980. A small gasifier is being purchased cooperatively with the Iron Range Resources Board, State of Minnesota, to experiment with harvesting, handling and processing energy crops and peat for fuel production.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0040
CROP PRODUCTION POTENTIAL FOR FOOD AND ENERGY ON MINNESOTA PEATLANDS
Farnham RS, Dept. of Soil Science, University of Minnesota, *St. Paul, Minnesota, 55101,* (MIN-25-023)
OBJECTIVE: Study the potential of new crops and varieties and their adaptability to Minnesota growing conditions on organic soil areas including fertilizer studies, disease and insect control, and other management studies. Study the potential of Minnesota peatlands for the production of peat and of biomass crops grown on peat as an alternate energy source. Use research information to recommend the type and location of peatlands for agricultural development and as an energy source.
APPROACH: Field and greenhouse studies will be instituted in St. Paul and at out-state locations (some on farmer's fields). Evaluate the potential of selected Minnesota peats for crop production, including biomass crops, under carefully controlled environmental conditions. Emphasis will be on evaluating promising new crops and varieties such as horticultural crops, wild rice, woody shrubs, sedges, and grasses. Management practices will include fertilizer trials, disease and insect controls, and weed control. Organic soils will be collected statewide for analysis and for greenhouse screening.
PROGRESS: Greenhouse and field studies were initiated to evaluate the suitability and adaptability of several vegetable, grain, and grass crops grown on Minnesota peatlands. Woody shrubs produced on peatlands including willow, alder, and hybrid aspen were established in two locations as a potential alternate energy source to be used in conjunction with peat. A small gasifier was purchased cooperative with the IRRB State of Minnesota in order to determine the economics of harvesting, transportation, and processing these fuel feedstocks for small-scale gasification which converts peat and biomass to liquid fuels (diesel fuel) and produces gas for heating purposes. Two woody biomass nurseries were established at the State of Minnesota Wilderness Valley Farms experimental fields in St. Louis County, MN and in Anoka County for propagation of cuttings from willow and alder. European black alder (Alnus glutinosa) seeds were obtained from a forest tree nursery in Finland (foundation seed stock) and planted in the Soils Dept. greenhouse. Some 1000 seedlings presently are growing and are to be planted at the two nurseries next summer. The biennial report of the D.N.R. supported study concerning agricultural reclamation of peatlands after mining of peat for energy was submitted to D.N.R. in October.
SUPPORTED BY: Minnesota State Government.

6.0041
EFFICIENT PRODUCTION OF METHANE FROM WATER HYACINTH JUICES USING ANAEROBIC DIGESTION FILTERS
Wolverton BC, National Space Technology Lab., U.S. National Aeronautics & Space Admin., *Biloxi, Mississippi, 39529,* (LC35-054)

OBJECTIVE: To develop an efficient method for producing energy from plant juices extracted from water hyacinth (Eichhornia Crassipes) biomass harvested from wastewater aquaculture treatment systems.
APPROACH: Laboratory experiments will be conducted to determine optimum size, configuration, microbial surface, digestion time, etc., of anaerobic digestion filters to provide biogas containing a high percentage of methane from plant juices.
PROGRESS: Laboratory tests have been conducted to determine the volume of methane generated from an anaerobic filter system receiving juice from water hyacinth plants.
SUPPORTED BY: U.S. Environmental Protection Agency. Office of Research & Development.

6.0042
BIOGAS PRODUCTION FROM ALLIGATOR WEEDS
Latif A, Dept. of Biology, Alcorn State University, *Lorman, Mississippi, 39096,* (NSG 8036)
OBJECTIVE: Develop a process to produce biogas and methane from the microbial anaerobic decomposition of aligator weeds and water hyacinths. Comparison of anaerobic filter digester with conventional anaerobic digester. Evaluation of various physical, chemical and biological factors on the rate, amount and percent composition of biogas produced from the microbial anaerobic decomposition of alligator weeds and water hyacinths by the use of anaerobic filter digester. Evaluation of fermented sludge as a supplemental feed.
APPROACH: Alligator weeds and water hyacinths will be chopped and placed in fermentation units. Starter seed will be used from the rumen content of a cow's stomach. Experiments will be conducted by using anaerobic filter digester as well as conventional anaerobic digester.
PROGRESS: Information obtained from the experiments indicate that the higher incubation temperature, pollution of alligator weeds and water hyacinths with heavy metals, addition of poultry droppings and cattle manure to the fermentation units, have increased the amount of biogas produced as well as the percentage of methane in biogas. Data also indicate the anaerobic filter digester is more efficient than a conventional anaerobic digester. Chemical analysis of sludge reveals. it is rich in protein and minerals and could be used as feed. For conclusive results, further studies are in progress.
SUPPORTED BY: U.S. National Aeronautics & Space Admin.

6.0043
BREEDING MAINTAINING AND INCREASING PRODUCTIVITY OF SWEET SORGHUM FOR SIRUP, SUGAR, AND ENERGY
Freeman KC, Broadhead DM, Zummo N, Agricultural Research, U.S. Dept. of Agriculture, *Meridian, Mississippi, 39301,* (7403-20090-005)
OBJECTIVE: Develop varieties of sweet sorghym with improved yield, juice quality, sirup quality, sugar quality, biomass yield, fiber quality, disease resistance, and agronomic characteristics. Determine the effects of various cultural practices upon the yield and quality of sweet sorghum varieities for sirup, sugar and renewable energy source.
APPROACH: Conduct comprehensive breeding and cultural studies program including evaluation of germ plasm. Testing selections and exotic importations and regional and interregional evaluation of varieties. Utilize information on inheritance of disease resistance and qualitative and quantitative traits, as Brix, sucrose, fiber, sirup, sugar, and alcohol per ton of stalks in the sweet sorghum breeding program. Utilize aspects of the culture of sweet sorghum for improved handling, processing, and management practices.
PROGRESS: Thirty (30) MN and 30 Mer. sweet sorghum cultivars and breeding lines have shown resistance to natural downy mildew (Sclerospora sorghi (Kulk) Weston and Uppal) infection. More than 100 cultivars and breeding lines, many with desirable agronomic characters are resistant to anthracnose and stalk red rot caused by (Colletotrichum graminicola (Ces.) G.W. Wils). Mer. 68-2, (Keller) a disease and insecticide-resistant, high sucrose sweet sorghum was released for potential sugar production. Mer. 76-6, tested at 10 locations for two years in Southeastern United States shows superior sirup quality and high yield. Midseason, high juice Brix cultivars showed adaptability and potential for energy production as far north as latitude 40 degrees; heavier yielding, late maturity cultivars showed adaptability south from 35 degrees N. Narrower row spacing with constant inter-row plant density increased plant population, biomass yield and stalk lodging per unit area, but showed no effect on juice Brix and sucrose content. Sweet sorghum stalk yield from consecutive annual planting on the same area was equivalent to stalk yield from annual rotation with soybeans for three years. Stalk juice Brix and sucrose of tillers were slightly higher than in primary plants. Bagging tiller panicles did not affect juice quality of corresponding primary plants.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0044
SWEET SORGHUM GERM PLASM MAINTENANCE
Freeman KC, Shaw JR, Agricultural Research, U.S. Dept. of Agriculture, *Meridian, Mississippi, 39301,* (7403-20090-007)
OBJECTIVE: Culture and maintain World Sweet Sorghum Germ Plasms Collection and provide germ plasm source seed to other researchers and germ plasm centers. Evaluate accessions for potential use as parent crosses to produce sirup, sugar, and energy. Classify accessions.
APPROACH: Maintain storage of exotic lines under optimum controlled temperature and humidity conditions. Conduct periodic germination tests of stored seed to project the need for reproducing lines to maintain seed viability. Make field and greenhouse plantings of exotic lines as needed to restore and maintain viable seed sources. Evaluate, collect, and computerize descriptor data of field planted accessions. Evaluate data to select potential parent lines for incorporation of desirable characteristics into breeding program.
PROGRESS: Forty nine (49) descriptors were collected on 507 accessions of sweet sorghum grown in the field in the Summer of 1979. Five hundred fifty (550) exotic accessions (extremely short-day plants) were grown in various locations perpetuating our seed supply of accessions that won't reproduce in environmental conditions of our location. Seed of 500 accessions were shipped to our National Seed Storage Laboratory at Fort Collins, Colorado. Germination percentages were determined on our entire collection to aid in our seed increase program and provide plant breeders with pertinent information regarding a particular accession.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0045
EVALUATION OF TREE SPECIES FOR ENVIRONMENTAL AMELIORATION AND ENERGY PRODUCTION
Miller EL, McCormick J, Agricultural Experiment Station, University of Nevada, *Reno, Nevada, 89507,* (NEV00671)
OBJECTIVE: Develop recommendations for using tree species in the production of energy and to modify environmental conditions.
APPROACH: Tree plantings with a reasonable known history will be evaluated as to performance and cultural requirements; tree sub-stations which represent distinctly different climatic conditions will be selected and a species testing program initiated. Replicated plots will be used at each location to determine tree performance in regard to survival, growth, cultural requirements, and pest resistance.
PROGRESS: Identification of trees planted in the low rainfall areas of Central and Northern Nevada is completed. Data and photographs of sample trees have been taken in seven communities. A master list of identifications includes the information for 17 communities. A report and manuscript of the survey findings is now being prepared. Identification is well along for three other areas: Elko, Ely, and Caliente. Reconnaissance work was done in the Las Vegas area. The tree investigation to date suggests a need for some new approaches and a need for some changes in the tree programs now undertaken by various public agencies. Some of these recommendations are being incorporated in the manuscript now being written. The cubic foot content of bole and branch wood in 27 native and introduced cottonwoods has been determined. A significant relationship between stem diameter (dbh) and cubic foot content has been computed. Examples of volume content include 10 inch dbh with 9 cu. ft. and 40 inch dbh with 220 cu. ft. Preliminary information indicates that a 20 inch dbh tree can be grown on typical agricultural land in 30 years. This is equivalent to 50 cu. ft. of wood or approximately 9.4 million Btus. Sixteen species including both deciduous and coniferous trees were planted at two locations in Northern Nevada. Based on first growing season results Rocky Mountain juniper had the highest survival rate (80%) with Siberian elm and black locust having survival rates over 50%.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0046
SEAWEED-CRUSTACEA POLYCULTURE
Ryther JH, Williams LD, Harbor Branch Foundation, *Lawrenceville, New Jersey, 08648,* (R/A-7)
OBJECTIVE: Research has been in progress for four years on culture of the red seaweed Gracilaria tikvahiae as (1) a source of the commercial polysaccharide agar, (2) as a biomass source for conversion to fuel (methane), as an advanced wastewater treatment system for removal of nutrients (N, P) from secondary sewage effluent mixed with seawater. A chronic problem in the Gracilaria culture, as in other forms of seaweed cultivation, is the incidental growth of epiphytes and epizoa on the seaweeds. The objective of the proposed research is to evaluate the performance of penaeid shrimp, stocked with the Gracilaria as post larvae, in controlling the epibiota and growth of the shrimp in the polyculture system with no supplemental feeding compared with their growth on defined diets of commercial feed. The economics of seaweed culture for any or all of the three above purposes is marginal at best, as is the commercial cultivation of penaeid shrimp grown on prepared feeds. Polyculture systems in which the seaweeds and shrimp are grown together with no supplemental feeding may prove cost-effective, helping to control one of the major problems in seaweed culture while eliminating the largest cost factor in shrimp culture.
PROGRESS: Preliminary results of the research to date, after spring initiation of experiments with shrimp (Penaeus duorarum) indicate that the animals living in seaweed alone (grown in enriched, circulating seawater) grew as well as those living in seaweed and fed a diet of commercial shrimp feed (Purina Exp. Marine Ration 25), and that both series grew better than did shrimp fed the ration alone but not living in seaweed. Epiphyte growth on the seaweed has not yet been a problem, even in controls without shrimp, so the effect of the animals has not been evaluated. Lobster experiments were delayed by unavailability of postlarvae and were initiated 6/25/80.
SUPPORTED BY: U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin.

6.0047
MARINE BIOMASS - NEW YORK STATE SPECIES AND SITE STUDIES
Squires DF, New York Sea Grant Inst., State University of New York, *Albany, New York, 12246,* (R/F-9)
OBJECTIVES: 1. Examine policy needs and options for the development of a marine biomass industry for synthetic natural gas production in New York. 2. Explore ways in which nearshore biomass production might be incorporated into other animal or plant aquaculture systems. Expected benefit is the development of a feasible system for the production of marine biomass for conversion to synthetic natural gas.
SUPPORTED BY: U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin.

6.0048
PRODUCTION OF BIOMASS FOR ENERGY ON LANDS OF LIMITED AGRICULTURAL USE
Lathwell DJ, Grove TL, Dept. of Agronomy, Cornell University, *Geneva, New York, 14456,* (NYC-125438)
OBJECTIVE: Characterize soil, water, and climatic properties of land resources of limited use for

traditional agriculture; evaluate the potential biomass production of plant species; match highly productive plants to available soil resources; and measure the productivity of selected wetland species experimentally.
APPROACH: Soil resources will be classified by constructing a matrix of soil characteristics including drainage, rooting depth, texture, slope, base status and climate. A matrix will be constructed to characterize plant species as energy sources. The plant matrix will be superimposed on the soil resource matrix. The results will allow identification of location areal extent of lands suitable for production of various species. Productivity and lime history of Typha and Scirpus will be measured.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0049
STUDY OF AN ANAEROBIC ATTACHED FILM EXPANDED BED DIGESTER FOR SEPARATION AND DIGESTION OF ALGAL BIOMASS
Jantzen D, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850*, (XB 9 8263 01)
OBJECTIVE: The objectives are: (1) to test the ability of an anaerobic attached film expanded bed (AAFEB) digester to separate, concentrate, and digest algal feedstocks produced under rapid growing conditions within a single reactor vessel; and (2) to estimate the conversion efficiency of the algae to methane. The tasks include: (1) constructing an AAFEB reactor with a volume of approximately 1 liter; (2) developing and operating a continuous culture algal feed production system, to provide a source of algae for the experiments; and (3) operating the reactor, at room temperature and with liquid flow rates varying from 0.5 liters per day to 10 liters per day, for a period of 3 months of stabilization and 6 months of testing.
SUPPORTED BY: U.S. Dept. of Energy.

6.0050
ASSESSMENT OF AGRICULTURAL FIELD TECHNIQUES APPLICABLE TO EMERGENTS
Raymond L, Columbus Laboratories, Battelle Memorial Inst., *Columbus, Ohio, 43201*, (XK 0 9360 0101)
OBJECTIVE: Emergent aquatic plants constitute a crop of great potential value--a highly productive crop that requires minimal or no tillage, fertilizer, seed, or cultivation. However, if emergent acquatic plants are to become a viable feedstock for fuel and fiber, much crop improvement and development is necessary. The objective is to assess the current agricultural production techniques employed in conventional aquatic agricultural systems and to determine if these techniques can either be utilized directly or modified to fit into emergent aquatic plant systems. The following production processes shall be reviewed: (1) planting and propagation; (2) cultivation and tillage; (3) harvesting and collection; (4) densification; (5) transportation; and (6) storage. The conventional field management techniques to be reviewed shall at least include: (1) rice; (2) floating rice; (3) wild rice; (4) watercress; (5) water spinach; and (6) chinese water chestnut. This study will also: (1) identify prospective emergent plant species for management (natural stands); (2) evaluate prospects for genetic manipulation, focusing on improvement of yield, biological and environmental tolerance, and physicochemical properties; (3) examine biological and environmental tolerances of natural crops; (4) determine availability of seeds and/or propagules for planting managed stands; and (5) project probable end-use and products.
SUPPORTED BY: U.S. Dept. of Energy.

6.0051
ENERGY POLICY, BIOMASS, AND AGRICULTURE: AN ECONOMIC ANALYSIS
Rask N, Ives E, Hitzhusen F, Ohio Agricultural Research & Development Center, *Columbus, Ohio, 43216*, (OHO00650)
OBJECTIVE: Determine the impact of present and evolving energy policies on agriculture; analyze the economics of selected crop biomass options; delineate the role of agriculture in future energy strategies.
APPROACH: Partial equilibrium market analysis of specific policy issues with identification of nonmarket effects; production and conversion cost analysis of selected biomass energy options, domestically, in major agricultrual exporting countries, and in selected Fourth World countries. Market analysis of international agricultural trade and domestic agricultural resource allocation implications of energy production from biomass as world energy prices rise. Identify (from original and/or existing research) mutually comparable measures of cost and important non-market implication (environment, public health and safety, national security) of energy sources, including biomass, which may play significant roles in alternative energy futures. Use this information to identify the cost and non-market trade-offs among selected broad energy strategies which have reasonable likelihoods of being followed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0052
ECONOMIC EVALUATION OF FOREST MANAGEMENT ALTERNATIVES ON HARDWOOD TIMBER TRACTS IN THE NORTHEAST
Worley DP, Northeastern Forest Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Delaware, Ohio, 43015*, (NE-4202)
OBJECTIVE: Determine the income potential for management of forest lands in Northeast for timber and other uses under a variety of situations comprising different combinations of types, sites, tree characteristics, markets, owner objectives, and land management practices.
APPROACH: Improve the awareness of small woodland owners of the income-producing potential of their hardwood stands by developing an automated timber management system for small woodlands. Develop timber quality and value information for planning the economic management of hardwood stands by evaluating existing hard data for sawtimber quality, by developing quality measures for young stands and by initiating studies to test the effect on timber quality development of existing timber management practices. Develop relevant value and price information for forest valuation and management planning by analyzing timber product price changes through time by relating grade lumber markets and prices to outside factors as the CPI and other national economic indicators. Improve the economic information for planning forest protection and for planning forest management for nontimber uses.
PROGRESS: Although it is caused by a fungus and is transmitted primarily by a bark beetle, Dutch elm disease is more of a management problem than either a fungus or an insect problem. Continued lack of good management tactics contributes more to the demise of our elm population than any other factor. Even-age management can be a valid alternative for northern hardwoods, depending on the value-set within which the owner makes his choice. Management must consider both silviculture and economics on deciding which trees to grow and how large to grow them. Financial maturity concepts and value-change expectations are tools for evaluating silvicultural recommendations. The AID (Automatic Interaction Detection) model is useful for segmenting tree mortality and timber value loss that are related to insect infestations into stand-variable characteristics which are meaningful to forest managers. Current diameter-limit cutting practices can be improved by using flexible diameters that follow financial maturity quidelines. A good rule of thumb for sawlog operations is to hold trees until they are at least about 16 inches dbh (have a minimum stump diameter of about 19 inches). To help meet the energy cruch, "firewood gardens" could be planted and managed within residential and industrial areas.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

6.0053
PROJECT ON MARINE BIOMASS
Raymond L, Re Entry and Environmental Systems Division, General Electric Co., *Philadelphia, Pennsylvania, 19101*, (XK 0 9350 0101)
OBJECTIVE: The overall objective is to develop integrated processes (including feedstock production, harvesting, and conversion) to produce methane from seaweed that are commercially cost competitive with other alternative energy sources. To accomplish this, quantitative determinations are to be made through direct experimentation and evaluation of concepts for feedstock production, harvesting, conversion, and by-product recovery, along with essential supporting technologies required by integrated feedstock-to-product process systems. The technical, economic, and energy requirements of the system are also to be determined. Additional objectives are: (1) to determine if macroalgal feedstock can be obtained in sufficient quantity and yield to demonstrate a strong economic future of ocean farm systems; (2) to confirm that ocean farms can provide net energy gains; and (3) to determine that microalgae can be harvested and converted to methane at costs competitive with other alternative energy sources. The general concept to be investigated in the marine-farming area is the growing of kelp on suspended artificial substrates positioned in deep ocean waters, utilizing nutrients obtained from artificially upwelled deep ocean waters. Tasks are: (1) to make engineering modifications required in order to make the Gas Research Institute's existing offshore test farm (OSTF) suitable for kelp growth and survival in the open ocean; (2) to collect basic laboratory support data; and (3) to continue the development of kelp-to-methane conversion systems. Conversion approaches include: (1) development of inocula capable of increasing methane generation rates and yields; (2) development of digester systems producing optimum methane yields and rates; and (3) determination of the relationship between water motion and nitrate uptake.
SUPPORTED BY: U.S. Dept. of Energy.

6.0054
NET ENERGY ANALYSIS OF FOREST BIOMASS AS A SOURCE OF ENERGY AND/OR CHEMICALS
Bowersox TW, Rishel LE, Blankenhorn PR, School of Forest Resources, Pennsylvania State University, *University Park, Pennsylvania, 16802*, (PEN02369)
OBJECTIVE: Conduct a net energy analysis by balancing the energy inputs for selected forest biomass cultural strategies against the potentially recoverable (energy outputs) energy for selected biomass conversion strategies in order to recommend a management and conversion strategy with the most favorable energy balance.
APPROACH: A net energy analysis will be performed on selected forest biomass management and energy conversion (or production of chemicals) strategies by balancing the energy inputs against the energy outputs. Criteria will be established for recommending a management and conversion strategy with the most favorable energy balance.
PROGRESS: The objective of this study is to conduct a net energy analysis by balancing the energy inputs for selected forest biomass cultural strategies against the potentially recoverable (energy outputs) energy for selected biomass conversion strategies in order to recommend a management and conversion strategy with the most favorable energy balance. Estimates of biomass yields using the available literature for selected cultural investments (control, fertilization, irrigation, and fertilization/irrigation) are being established. In addition, the effects of cultural investments and moisture content on selected conversion strategies (direct incineration, pyrolysis, gasification, and liquefaction) for the energy balance are being analyzed. These investigations will provide a base for additional analyses.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0055
SELECTED PROPERTIES OF POPULUS HYBRIDS GROWN FOR USE AS A SOURCE OF ENERGY AND CHEMICALS
Labosky PJ, Rishel LE, Blankenhorn PR, School of Forest Resources, Pennsylvania State University, *University Park, Pennsylvania, 16802*, (PEN02380)
OBJECTIVE: Determine the clonal variations, as a function of age, among seven Populus hybrids in gross heat of combustion, ash content, macronutrient composition, and chemical composition.
APPROACH: Wood, bark, and wood bark

specimens, as a function of age, from seven clones of Populus hybrids growing on experimental plots in central Pennsylvania will be obtained for subsequent gross heat of combustion, ash content, macronutrient, and chemical analyses. Variations among the seven clones in the wood, bark, and wood/bark specimens as a function of age will be established and analyzed.
PROGRESS: The objective of this study is to determine the variations in energy and chemical contents, as a function of age, among seven Populus hybrid clones. Gross heat of combustion, ash content, macronutrient content (P, K, Ca, and Mg), and chemical content (total extractives, holocellulose, alpha cellulose, and lignin) values for wood, bark, and wood/bark specimens are being determined as a function of age (1 through 7 years) for the seven clones. Holocellulose, alpha cellulose, and lignin values remain to be determined. Variations within and among the seven clones will be analyzed after all data have been assembled.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0056
ENVIRONMENTAL IMPACT OF APPLICATIONS OF MUNICIPAL WASTEWATER AND SLUDGE IN FORESTS
Sopper WE, School of Forest Resources, Pennsylvania State University, *University Park, Pennsylvania, 16802,* (PEN02214)
OBJECTIVE: Evaluate the long-term effects of spray irrigation of sewage effluent and sludge on the forest ecosystem. Determine the feasibility of using municipal wastewater to produce mini-rotations of poplar for wood fiber production.
APPROACH: Effects of spray irrigation of sewage effluent and sludge during the past 14 years in a mixed hardwood forest, a red pine plantation, and a white spruce stand will be evaluated. Tree growth and vegetation changes will be determined. Foliar and tree stem wood analysis will be used to determine nutrient uptake and storage. Soil analyses will determine changes in chemical properties. Soil-water percolate analyses will determine renovation efficiency of the forest ecosystem. Special studies will be conducted on accumulation and decomposition of the forest floor and influencing factors. Hybrid poplar cuttings planted with equivalent growing space of 1, 2, and 4 sq. ft. in 1973 will be evaluated to determine the effect of spray irrigation of sewage effluent on wood fiber production.
PROGRESS: The feasibility of increasing woody biomass production from forest energy plantations through the use of municipal wastewater irrigation was investigated in central Pennsylvania. Energy plantations were established to evaluate the growth and development of hybrid poplar cuttings planted at densities of 0.09, 0.19, 0.37 m of growing space per tree. Treated municipal wastewater was used to irrigate half of the plantations during the growing season (April to October) at the rate of 5 cm per week. Wastewater irrigation significantly increased diameter and total height growth. Total woody biomass (stemwood, bark, and branches) production was more than doubled by wastewater irrigation. Results also indicated that the hybrid poplar energy plantations were very efficient in renovating the wastewater for direct recharge to the groundwater reservoir. Results indicate that the potential annual woody biomass production could reach 29 to 35 dry tons per hectare. The present field study indicates that there is a common relationship between the two concepts of land treatment of municipal wastewater and silvicultural energy farms and that the combination of the two concepts provides for a beneficial cost-effective solution.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0057
PRODUCTION OF SUGAR CANE AND TROPICAL GRASSES AS A RENEWABLE ENERGY SOURCE
Alexander AG, Gonzalez Molina C, Dept. of Agronomy & Soils, University of Puerto Rico, *Mayaguez, 00708, Puerto Rico,* (PR-C-00481)
OBJECTIVE: Determine the agricultural and economic feasibility of mechanized, year-round production of dry biomass, through the intensive management of surgar cane and napier grass as tropical forages. Examine alternate tropical grasses as potential sources for intensive biomass production.Select and breed new sugar cane clones having superior biomass productivity as their main attribute.
APPROACH: In greenhouse trials, tropical grass species having superior growth potential (on an annual basis and as frequently recut forages) will be identified. Optimal regimes for nitrogen, water, row spacing, harvest frequency, and chemical growth regulators will be defined with superior candidate clones in field plot trials. Mechanization requirements and costs for the two or three superior candidate clones emerging from greenhouse and field-plot experiments will also be evaluated in field trials.
PROGRESS: Tropical grasses from Saccharum and related genera are being evaluated as candidates for intensive production of solar-dried biomass. Categories of candidates include short-, intermediate-, and long-rotation species for intensive co-production with conventional food commodities. Minimum-tillage candidates are also sought for extensive production on marginal lands. The hybrid forage grass Sordan 70-A is the outstanding short-rotation plant tested to date. It completes the tissue-expansion and maturation phases; within 10 weeks, yielding at least 4 tons of oven-dry biomass per acre. Napier grass (var. Common Merker) is a promising intermediate rotation crop which may be exceeded by several napier grass hybrids. Interspecific Saccharum hybrids and the species S. spontaneum and S. sinense are being investigated for long-rotation and minimum tillage cropping. Direct comparisons of sugar cane hybrids with napier grass indicate that sugar cane is an inferior candidate for short-term production of tropical forages. Sugar cane responded well to narrow spacing for about 6 months after seeding. Napier grass failed to respond to close spacing. Both species increased yields with decreasing frequency of harvest. Fertilization rates based on conventional sugar and forage production data were inadequate to sustain maximum biomass yields.
SUPPORTED BY: Puerto Rican Government.

6.0058
COOPERATIVE FOREST MANAGEMENT RESEARCH
Irwin J, Forest Service, U.S. Dept. of Agriculture, *Aiken, South Carolina, 29801,* (002150)
OBJECTIVE: The objective of this activity is to accomplish research having direct application to the SRP Forest Management Program and to biomass management in the southeast. Seven research projects conducted by senior foresters from the USFS are cooperatively supported by this program. The research is designed to determine the ecological effects of substituting nutrient sources such as sewage sludge and nitrogen-fixing legumes for petroleum-intensive fertilizers. Nutrients and metals transport are analyzed in the plant, soil, and water. Additional research addresses the factors affecting adaptation of vegetation to severely distressed and exhausted soils, such as are found in borrow pits and after intensive cultivation. Environmental factors affecting disease resistance in trees are also being investigated in order to minimize or prevent crop failures in woody biomass production.
SUPPORTED BY: U.S. Dept. of Energy, Office of Health & Environmental Research.

6.0059
BREEDING AND EVALUATION OF SWEET POTATOES FOR FRESH MARKET AND INDUSTRIAL USES
Hamilton MG, Edisto Experiment Station, Clemson University, *Blackville, South Carolina, 29817,* (SC00437)
OBJECTIVE: Develop soil insect, disease, and nematode resistant sweet potato cultivars and germ plasm for fresh market. Develop high yielding, high starch cultivars for alcohol production or other industrial purposes.
APPROACH: Polycross progeny will be evaluated in the greenhouse, field, laboratory and storage for desired traits. Emphasis will be placed on yield, shape, flesh color, general appearance, culinary quality, storage, and sprouting ability in combination with major emphasis on resistance to principal soil insects, nematodes, and diseases for fresh market types. Major emphasis will be placed on yield, starch content, resistance to rotting, and storage and sprouting ability for industrial types.
SUPPORTED BY: South Carolina State Government.

6.0060
PLANT BIOMASS AND ENERGY CONSERVATION
Constantin MJ, U.S. Dept. of Agriculture, Comparative Animal Research Lab., University of Tennessee, *Oak Ridge, Tennessee, 37830,* (002655)
OBJECTIVE: Biomass, the result of solar energy storage by plants through photosynthesis, represents a unique, renewable resource which can be converted either to fuels or to chemical feedstocks. Our present knowledge of the biological limits to exploitation of this resource is inadequate, and further research is required to adapt biomass production as an alternate energy source. The objective of this project is to gain an understanding of the biological processes involved with biomass, and to develop methods leading to improved biomass yield and quality. Our attention is currently focused on: (1) the effects mechanism of sulfur dioxide on photosynthesis, and the assessment of the feasibility of developing mutants resistant to this pollutant; (2) the regulation and synthesis of aspartate-derived amino acids and the identification of methionine-rich protein fractions; (3) development of screens to determine genetic resistance to energy pollutants and environmental stress as well as improved protein quantity and quality; and (4) regulation of photosynthate partitioning into starch, cellulose or protein.
SUPPORTED BY: U.S. Dept. of Energy, Office of Energy Research.

6.0061
SUGAR/ENERGY CROP PHYSIOLOGY
Creelman RA, Miller FR, Reeves SA, Agricultural Experiment Station, Texas A & M University, *Weslaco, Texas, 78596,* (TEX06360)
OBJECTIVE: Breed for and develop high energy (H.E.) sorghum, characterize sucrose and fermentable solid build up in H. E. sorghum plants, develop whole plant utilization of H. E. sorghums for food, feed, fuel and fiber and develop crop rotations that include H. E.
APPROACH: The use of the sorghum conversion program genetic material is available for breeding at College Station by Dr. F. R. Miller. Stalk sugars and fermentable solids will be determined by UV spectrophotometric method after enzymatic breakdown. Study potential uses of materials and by products for more complete plot utilization. This project will combine with H-6116 Double Cropping in the Lower Rio Grande Valley of Texas.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0062
PRODUCTION OF SUGAR AND BIOMASS ENERGY FROM SWEET SORGHUM AND SUGAR CANE
Smith BA, Lime BJ, Food Crops Utilization Research Lab., U.S. Dept. of Agriculture, Agricultural Research, *Weslaco, Texas, 78596,* (7202-20520-001)
OBJECTIVE: Develop continuous pilot-plant procedures adaptable to factory production of sugar from sweet sorghum and sugar cane, and determine crop potentials for biomass energy production.
APPROACH: Select and adapt continuous pilot-plant processing parameters of temperature, pH, rate, and additive use to provide maximum removals of impurities from juices and syrups derived from mechanically harvested sugar crops. Compare processing procedures for separating impurity-laden sediments from process liquors and determine effect on raw sugar recovery, directing specific attention to separating clarifier mud from filtrate, and aconitate from sweet sorghum syrup. Provide analytical and processing data to assist in selecting superior sweet sorghum and sugar cane varieties and horticultural practices for commercial sugar production and for their potentials as biomass energy source crops.
PROGRESS: Intensive milling of seed-free sweet sorghum stalks with essentially all leaves provided juices which simulated those obtained from unburned, mechanically harvested sweet sorghum. These juices performed well in laboratory- and

factory-scale processing tests, but levels of non-sugar, non-starch, organic materials remaining in the processed syrups were increased, indicating a potential for reduced recoveries of crystalline sugar, but showing no measurable adverse effect for fermentation of available sugars to ethanol. Data from limited sweet sorghum processing tests indicated that where partial rather than maximum crystalline sugar recovery was proposed, some operations might be deleted from the conventional processing scheme without adverse effect. Analytical data from sweet sorghum and sugarcane field samples provided Federal and State agencies with information needed for selections of superior varieties for commercial sugar or biomass production. Sweet sorghum tropical strain MN1500 continued to exhibit outstanding potentials for biomass production of fermentable sugars. Fermentation tests with sweet sorghum materials and various vegetable crops are providing data to indicate alcohol production potentials and the quality of the resulting stillage as feedstuffs.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0063
SUGAR CROP RESEARCH IN THE LOWER RIO GRANDE VALLEY OF TEXAS
Reeves SA, Texas A & I Univ. Coop. Res. Unit, Texas A & M University, *Weslaco, Texas, 77843*, (TEX06192)
OBJECTIVE: Develop improved varieties of sugar cane and sweet sorghum for sugar and syrup production in the Lower Rio Grande Valley of Texas. Determine the optimum cultural practices for maximum production of sugar from sugarcane and sweet sorghum in the Lower Rio Grande Valley of Texas.
APPROACH: Varieties will be brought into the Valley from throughout the world and evaluated in both field trials and laboratory analyses. Field trials and laboratory analyses will be used to determine the optimum cultural practices such as planting, cultivation, weed control, irrigation, and harvest aids.
PROGRESS: Sugar crops (sugar cane, sweet sorghum) are being investigated as a renewable source of biomass for the production of alcohol for energy and a variety of selection programs are aimed at increasing yields of sugar and biomass per hectar. Sixty-two new sugar cane varieties were imported into Texas from the following breeding programs: L.S.U. Agricultural Experiment Station, Louisiana U.S.A. U.S.D.A. Sugarcane Station at Canal Point, Florida and Houma, Louisiana, U.S.A. Mexico, Argentina and Brazil. These new varieties will be evaluated in a screen program for sucrose production. In 12 replicated sugar cane variety trials for the 1977-78 season, there were six sugar cane varieties which were outstanding; namely, L 61-49, CP 62-250, CP 66-315, CP 67-412, CP 68-350, CP 70-321. The use of plant biomass for the production of alcohol for energy is being investigated as a substitute energy source. Sweet sorghum varieties were tested for total biomass with a tropical sweet sorghum variety MN 1500 producing 40.0 MT/ha. Plant spacing trials with sweet sorghum indicated that an area of 0.15m to 0.20m per plant produces to maximum biomass yields per hectar. Sweet sorghum variety Rio produced a ratoon crop which was 50% less than the original plant crop in total biomass.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0064
DEVELOPMENT OF SUGAR BEET AND OTHER BETA SPECIES FOR ALCOHOL FUEL PRODUCTION
Doney DL, Theurer JC, Mumford DL, Dept. of Plant Science, Utah State University, *Logan, Utah, 84321*, (5521-20090-006)
OBJECTIVE: Evaluate sugar beet, fodder beet, and other representatives of the Beta family for production of total fermentable sugars. Determine cultural practices that will maximize fermentable sugar production with minimal energy input. Develop high-yield, disease-resistant breeding lines for fermentable sugar production.
APPROACH: Evaluate by field test and laboratory analysis existing sugar beet, fodder beet, and other genotypic representatives of the Beta family for fermentable sugar and potential alcohol production. Determine cultural practices, including nitrogen fertilization and plant density, that will maximize fermentable sugar beet and fodder beet cultivars. Develop, by appropriate breeding and selection methods, improved breeding lines for increased fermentable sugar production with sugar beet, fodder beet, and other Beta types. Incorporate curly-top resistance into high-fermentable, sugar-yielding genotypes.
PROGRESS: Two 120-day sweet-sorghum varieties tested under Utah conditions gave total biomass yields of 5.8 and 7.6 tons per acre and fermentable sugar yields of 2.1 and 2.7 tons per acre. Several seed lots of fodder beet and sugar beet X fodder beet hybrids were obtained from European seed companies to use in research experiments in 1980 and subsequent years. Local sugar beet lines and fodder beets have been crossed in seed isolation chambers for field evaluation in 1980.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

6.0065
HIGH PRODUCING SHRUBS OF THE WESTERN UNITED STATES FOR BIOMASS PRODUCTION
McKell CM, Inst. for Land Rehabilitation, Utah State University, *Logan, Utah, 84322*
OBJECTIVE: The general objective of this project is to continue to evaluate, under dryland field conditions, the productivity of giant shrub species and ecotypes from the rangeland of the Intermountain West. Secondary objectives are to: (1) determine the effect of row spacing and cultural practices on biomass productivity; (2) obtain seed and/or propagation materials from selected plants; (3) establish guidelines for the production of giant shrubs; and (4) prepare approximate cost estimates and biomass quality. Giant shrubs with high potential biomass yields will be planted at the Nephi Dryland Field Station. In addition, data will be collected from natural stands for comparing the productivity of managed versus unmanaged stands.
PROGRESS: Seedlings and/or cuttings for the selected biotypes were grown in the greenhouse until sufficient size was reached for field planting. Not less that 10 biotypes of each of seven species were planted at the Nephi Field Station. Two spacings were used, 3 ft. x 10 ft. and 6 ft. x 10 ft. for comparison of yield. The plantings are being cultivated annually to remove competing vegetation and growth measurements are being taken at the end of the growing season.
SUPPORTED BY: U.S. Dept. of Energy, Div. of Solar Technology.

6.0066
PRODUCTION OF BIOMASS FOR ENERGY ON ABANDONED FARMLANDS
Laing FM, Dept. of Botany, University of Vermont, *Burlington, Vermont, 05401*, (VT00905)
OBJECTIVE: Evaluate hardwood trees and shrubs providing highest biomass potential on short cutting cycles. Compare yields from native against introduced species. Evaluate harvesting, transportation, and utilization of biomass. Examine portions of yield as potential feed stuff. Model economic comparisons from land preparation to utilization.
APPROACH: In randomized design measure growth rate and sprouting ability for coppice harvest. Include fertilizer and spacing trials. Determine Btu content. Maintain untreated areas of uncultivated species for yield comparisons. Evaluate possible cultivation and harvesting techniques. Compare known transportation and utilization costs with projected acre-yields. Analyze bark and foliage samples for feed value.
PROGRESS: Plot areas have been prepared on differing soil types and at varying elevations for Spring 1979 planting. Candidate hardwood species will be planted for growth measurements. Plant spacings and fertilizer effects, including sewage sludge, will be evaluated. Trials of interplanting of leguminous species with energy species are planned. Growth measurements of coppices in the wild have been made to establish comparative values. Seeds of native trees have been collected and are being stratified for spring germination. Seeds, seedlings and cuttings from commercial sources will also be use in plot trials.
SUPPORTED BY: Vermont State Government.

6.0067
ADAPTATION OF CONVENTIONAL AND NOVEL HARVESTING SYSTEMS TO CHANGING SOUTHERN FOREST CONDITIONS
Walbridge TA, Stuart WB, School of Agricultural & Life Sciences, Virginia Polytechnic Inst. & State University, *Blacksburg, Virginia, 24061*, (VA-0632260)
OBJECTIVE: Analyze by mathematical models the response of conventional harvesting machines and systems to terrain and timber harvested. Evaluate forest stand structure, tree engineering characteristics, and product potential of commercially important species in the region. Explore novel approaches to silvicultural and raw material needs through harvesting equipment.
APPROACH: Conduct production studies on selected machine and system types across their normal working ranges. Develop mathematical models based on these studies. Then, by simulation, develop parameters for machines application and document voids in needs by available machines. Determine weights, centers of gravity, and yields of full trees and tree segments for selected commercial trees of the South and Appalachians. Prepare and test through simulation (and field prototypes, if possible) novel machine designs for whole trees, chips, etc.
PROGRESS: The evaluation of temporary stream and drain crossing requirements for skid trails and temporary access roads is nearly complete. A prototype soft crossing structure has been constructed and will be tested in 1979. Analysis of shearing forces required to sever individual and multiple stems during baling of logging residues is in progress. A study of the potential of coppice growth in Appalachian hardwoods to produce biomass for energy has been initiated. A reliability model for feller bunchers and whole tree chippers is being developed to afford maintenance and repair strategies to harvesting personnel. The design of an in-feed mechanism for an in-woods baler for logging residues is complete. A prototype will be constructed in 1979. A study to determine the efficiency of field drying as a method of preparing woody biomass for fuel was initiated. The potential of modifying conventional harvesting systems for the production of fiber and fuel is 50% complete. A comparison of severance devices for complete recovery of woody biomass was initiated. Expected completion date June 1979. A mathematical model of procurement, transportation and storage of woody fuels from forest to plant is being developed. Expected completion is 1980.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0068
AQUACULTURE OF SEAWEEDS ON ARTIFICIAL SUBSTRATES
Mumford TF, Waaland JR, State Dept. of Natural Resources, *Olympia, Washington, 98504*, (R/A-12)
OBJECTIVES: Long-range: To develop commercially feasible aquaculture techniques to grow seaweeds used for the extraction of useful products or directly for food, food supplements, fertilizer or biomass conversion. Techniques for growing seaweeds on artificial substrates and in combination with tank-pen culture will be developed. 1981: 1. Continue research to incease yields from nets seeded with Iridazea and Gigartina. 2. Improve bottom and surface-oriented structures and explore large-scale structures for seaweed culture. 3. Continue economic analysis of structures, production costs, and marketing possibilities. 4. Begin site analysis by bioassay techniques for industrial-scale culture. 5. Diversify kind of algae grown. 6. Investigate and test structures for polyculture of seaweeds with mussels, oysters, abalone, shrimp, and salmon. 7. Test harvester for seaweeds on artifical substrates. 1982: 1. Continue those items given for 1981. 2. Set up large-scale facility for seeding of nets with Iridaea and Gigartina.
This research will benefit the established phycocolloid industry (FMC Corp. Stauffer Chemical, Genu Products, American Agar) by provicing a stable, domestic supply of high-quality carrageenophytes and agarophytes now in short supply, especially those that will yield lambda carrageenan. New local industry will be created by the culturing, harvesting and processing of seaweeds. Technology that has been developed may be used for the production of seaweeds for food, fertilizers, and biomass conversion. This research will enable

the Washington Department of Natural Resources to better manage the marine resources of the state. More diverse uses of state-owned tidelands and bedlands and non-exploitative uses of natural populations will come through aquaculture of seaweeds. Economic returns to the states will come through several options: 1. Lease of state-owned tidelands or bedlands for seaweed aquaculture. 2. Sale or lease of seeded nets to private companies, 3. Sale or lease of harvesting rights to seaweed on DNR-owned nets, 4. Creation of jobs in the pilot-scale operation planned for 1982-3. Personnel will be trained in seaweed aquaculture through full-time or part-time employment and student work-study, or internship programs with local colleges.
SUPPORTED BY: U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin.

6.0069
INTENSIVE CULTURE OF DOUGLAS-FIR AND ASSOCIATED SPECIES
DeBell DS, Curtis RO, Miller RE, Pacific Northwest Forest & Range Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Olympia, Washington, 98501*, (PNW-1207)
OBJECTIVE: Determine best growth of Douglas-fir and associated species for a broad range of management objectives.
APPROACH: Increase production in young Douglas-fir forests through control of tree spacing and level-of-growing stock. Increasing timber-growing capacity of Douglas-fir sites through soil management and improvement. Conversion of mature young-growth Douglas-fir to seedling stands through the shelterwood system.
PROGRESS: A 51-year record in stands planted at 4x4 through 12x12-foot spacings shows beneficial effects of wide initial spacing and detrimental effects of carrying too many trees. Wide spacings produced larger trees and greater volumes. Research shows that growth of most young-growth Douglas-fir stands can be increased 10 percent or more by nitrogen fertilizer. Continued research in tree nutrition and fertilization will improve cost effectiveness of forest fertilization and contribute to increased future timber production. Studies of biological nitrogen fixation to supplement application of synthetic N fertilizers are accelerating. Red alder comprises 15 percent of the commercial forests of western Oregon and Washington. It provides material for furniture, lumber, plywood, and pulp, but the industry does not have steady markets or reliable sources of raw material. Rapid early growth may make alder increasingly attractive for wood fiber and energy supplies. It is an effective fixer of atmospheric nitrogen and may help reduce root rot problems of conifers. Experimental coppice yields of black cottonwood and red alder biomass ranged from 1.7 to 6.2 ovendry tons per acre per year. Applications of pulp and paper mill sludge increased cottonwood yields but decreased alder yields. Irrigation increased growth of both species.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

6.0070
ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES
Whetzel V, Dept. of Resource Management, West Virginia University, *Morgantown, West Virginia, 26506*, (NRE-43-309-54-01)
OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood for home heating. Analyze the economic feasibility of energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.
APPROACH: Assess the economic resource use and environmental implications of public programs to encourage "energy farms." Develop regional reports on current land and water use, the economic implications for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregion linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empirical studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

6.0071
POTENTIAL OF HERBACEOUS BIOMASS FOR ENERGY PRODUCTION AND CONSERVATION
Collins M, Kaplan S, Dept. of Agronomy, University of Wisconsin, *Madison, Wisconsin, 53706*, (WIS025555)
OBJECTIVE: Study the potential of annual crops seeded following pea harvest for herbaceous biomass production; and evaluate the currently available herbaceous biomass resources for Wisconsin.
APPROACH: A field study will be initiated at the Arlington Experimental Farm. Peas seeded in May will be harvested in late June. Forage sorghum, sorghum-sudangrass hybrid, male sterile corn, brown midrib corn, soybean, and male sterile corn, field bean and male sterile corn and normal corn (95-RMI) will be compared for biomass production potential. Yield data will be collected for each treatment and the herbage produced will be analyzed for cellulose, hemicellulose, lignin and total nonstructural carbohydrate concentrations. In vitro dry matter, cellulose and hemicellulose disappearance will be determined. Objective 2 will be accomplished by compiling data available from the literature and from other sources of statistical information for Wisconsin. Attention will be given to crop residues and to crops produced specifically for their energy value.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

6.0072
INTENSIVELY CULTURED PLANTATIONS FOR FIBER AND ENERGY
Dawson DH, North Central Forest Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Rhinelander, Wisconsin, 54501*
OBJECTIVE: The research objective is to develop and evaluate cultural methods that would assure high survival and vigorous growth of plantations of Populus clones that have been identified in preliminary screening studies as promising for the Lake States area. The specific objectives are: (1) evaluation of different Populus clones; (2) evaluation of effectiveness of various site preparation methods, cover crops, and mechanical cultivation in controlling competing weeds; (3) evaluation of various cutting propagation methods; and (4) evaluation of seasonal effects of plantation establishment and growth.
PROGRESS: Field studies underway are providing information useful for devising a system for establishing intensively cultured plantations of hybrid Populus. Tests with the growth regulators Ethrel and Accel have shown that both are effective for increasing greenwood cutting production of hybrid poplar stock plants. Rooting studies with greenwood cuttings of a difficult-to-root Populus alba clone demonstrated that stem section cuttings (with or without hormone treatment) from lower portions of the stem rooted better than cuttings from the tip portion. Summer fallowing retarded quackgrass reinfestation. Applications of preemergent linuron followed by postemergent roundup, and linuron followed by cultivation effectively controlled weeds in plantations. Energy budgets were prepared for intensively cultured hybrid poplars and jack pine and for natural red alder stands. The energy gains corresponded to 43, 34, and 31 barrels of oil per hectare per year for the poplar, jack pine and red alder, respectively. Net energy gains were linearly correlated with energy invested in cultural practices.
SUPPORTED BY: U.S. Dept. of Energy, Oak Ridge National Lab.

6.0073
INTENSIVELY CULTURED PLANTATIONS FOR BIOMASS AND ENERGY PRODUCTION
Hansen E, North Central Forest Experiment Station, U.S. Dept. of Agriculture, Forest Service. *Rhinelander, Wisconsin, 54501*, (NC-1112)
OBJECTIVE: Develop the most efficient and economically feasible method for establishing planted stands and producing maximum wood and biomass per acre from them.
APPROACH: Select woody species or species variants showing rapid juvenile growth, ease of reproduction, and good prospects for genetic improvement. Using intensive culture, determine effects of various spacings, rotations, nutrient levels, and irrigation on biomass yields.
PROGRESS: Time of collecting Populus hardwood cutting has been found to affect rooting performance of several Clones. Generally rooting precentage and number of roots per cutting were least for November collections and most for collections in March, but performance of collections made in January or February were only slightly less favorable than cuttings taken in March. Investigations of the effectiveness of Accel, a cytokinin, for stimulating auxillary bud break on Populus stems (for increased cutting production) have shown that two to three times as many cuttings can be produced in the greenhouse as compared with standard methods for cutting production. Second year plantation establishment studies show that the better site preparation methods are a combination of chisel plowing and spike toothed harrowing, or molboard plowing, discing and spike toothed harrowing. Mechanical cultivation and several herbicies (particularly linuron) provided some of the better weed control. Paper mill effluent can be disposed at high rates (more than 2 feet per week) on sand soils and still produced good growth or Populus. Organic particulate matter, nitrogen and phosphorus are effectively removed from the effluent. Natural stands of red alder are more efficient, as measured by a ratio of energy output/energy input, than hybrid poplar or jack pine plantations in storing energy in their biomass.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

6.0074
PHYSIOLOGY AND RAW MATERIAL EVALUATION OF INTENSIVELY CULTURED PLANTATIONS
Isebrands JG, North Central Forest Experiment Station, U.S. Dept. of Agriculture, Forest Service, *Rhinelander, Wisconsin, 54501*, (NC-1152)
OBJECTIVE: Provide criteria for the improvement of quantity and quality of yields from intensively cultured plantations based upon the evaluation of physiological parameters and utilization potential.
APPROACH: Develop parameters for the selection or breeding of ideotypes for intensive cultured plantations by studies of canopy density and architecture, photosynthesis and respiration, photosynthate distribution, and material quality. Determine the material quality of intensively cultured plantations in relation to genotype, spacing, cultural practices, and rotation.
PROGRESS: Research has shown that raw materials produced by short rotation intensive culture (SRIC) Populus plantations are suitable for a variety of industrial end products, including kraft pulp, structural flakeboard, fuel, and animal feed supplements. A case study was conducted on 5-yr-old SRIC Populus planted at 1.2 m spacing. The percent composition of the total aboveground biomass (G42 mt/ha) was 72% wood, 18% bark, and 10% leaves. Vacuum airlift segregation (VAS) of the total biomass provides industrial managers with several integrated utilization alternatives including pulp, fuel and animal feed. Photosynthesis, CO(2) for two years. Photosynthetic rates (Ps) that are moderate to high for C3 plants were measured. Diurnal Ps were related to leaf age and position, season, stomatal conductance, and photon flux density. Equipment and sampling procedures useful to researchers conducting field Ps experiments were perfected. Also a technique for minimizing ethylene diffusion from gas tight vials was discovered.
SUPPORTED BY: U.S. Dept. of Agriculture, Forest Service.

6.0075
ENERGY PLANTATION HANDLING SYSTEMS
Crafoord C, Ergonomi Design Gruppen AB, *Bromma, Sweden, S16114 Bromma*, (53 3065 513)
OBJECTIVE: To develop equipment to handle energy plantations on small and medium sized sites.
APPROACH: To be able to develop a harvester for a short rotation forest, a study is to be carried out to collect data about critical components and functions. The result of the study is to be used as a base when working out an inquiry to manufacturers to give estimations for making a prototype harvester.
PROGRESS: The first and second phases have been presented in the form of slides and a report titled: "Energy Plantation Handling Systems, Needs and Ideas, Outline to a Harvester".
SUPPORTED BY: Namnden for Energiproduktionforskning.

6.0076
MACHINES FOR HARVESTING BIOMASS FROM SHORT-ROTATION FORESTRY - PHASE V
Magnusson L, Jorgensen KG, Olsson C, Dept. of Energy Technology, Sikob AB, *Sollentuna, Sweden, S19178 Sollentuna*, (53 3065 285)
OBJECTIVE: An experimental study of central problems of harvesting short-rotation forests on former wet-lands, - tests of cutting speed, damage to stumps, etc., with a prototype cutting head (circular saws, rotating knives), - tests of bundling the harvest continuously in a prototype bundling machine, - limited tests of tracked vehicles on actual types of land.
APPROACH: Prototype experiments. As a basis for the design of a full-scale prototype harvester to be used in the planned Swedish pilot farms.
PROGRESS: Phase V is a direct continuation of phase III and IV, where the prototypes were developed, the cutting head tested, and the bundling machine manufactured and initially tested.
SUPPORTED BY: Namnden for Energiproduktionforskning.

6.0077
SHORT ROTATION FORESTRY ENERGY PILOT FARMS - PHASE II - SOIL PREPARATION AND PLANTATION
Westerberg I, Orth L, Lundin A, Forest Technology Section, Sodra Skogsagarna, *Vaxjo, Sweden, S35189 Vaxjo*
OBJECTIVE: Test and development, in practical scale, of: 1) intensive cultivation to get the high yields indicated by earlier small scale cultivations; 2) methods and equipment for harvest, transport, storing and use; 3) environmental influence; 4) economy of the total system.
APPROACH: (Phase I) Finished. 4/79-3/80. Choice of ground and planning. (Phase II) Above. Soil preparing, as in agriculture, on former agriculture land. Total area 100 ha. 5/80-10/80. Stitching (Salix sp.) 11/80 and 4-5/81. Fertilizing and weed-grass control from 6/81. (Phase III) To be decided at end of ph II. 1982-84. Care, fertilizing, harvest, transport, storing and final use. Results belong to supporting agency (NE) for guiding political decisions of future energy sources.
SUPPORTED BY: Namnden for Energiproduktionforskning.

6.0078
INVENTORY OF BIOMASS FOR FUEL - PHASE IV
Hagglund B, Lindroth S, Dept. of Forest Survey, Swedish University of Agricultural Sciences, *Umea, Sweden, S90123 Umea*, (53 3065 274)
OBJECTIVE: The project shall provide all information needed for the assessment of (1) areas suitable for growing wood for energy production (2) existing quantities of wood suitable for energy production. Criteria for selection of suitable areas and wood resources are to be specified by experts on nature conservation, on growing wood for energy production, on machine construction and on energy producton.
APPROACH: Main elements of the project are: (1) Identify information needed and define criteria to be used. (2) Collect and evaluate existing knowledge. (3) Collect further information needed. (4) Forecast future prospects as to the availability of wood for energy production.
Phase I: Prepare plan for the whole project covering a period of at best 3 years. Prepare data collection in conjunction with the field work in 1978 of the Swedish National Forest Survey. (Finished in September 1978); Phase II: Analysis of data collected in 1978. Analysis of method test. Initiation of data collection in 1979, including tests of ground condition classifications. Synthesis of restrictions which can delimit available areas for short rotation forestry (Finished in June 1979); Phase III: Continued data collection and evaluation of information collected earlier. Continued studies of restrictions delimiting use of potential areas for short-rotation forestry. Application of developed functions for estimation of biomass in whole trees and parts of trees. (Finished in March 1980); Phase IV: Continued data collection in 1980 within the Swedish National Forest Survey. Evaluation of data from special land inventories in 1979. Continued analysis of restrictions influencing land availability. Continued analysis of biomass in whole and parts of trees. The phase is ending with a major report of the work throughout all the phases of the period.
SUPPORTED BY: Namnden for Energiproduktionforskning.

7. BIOMASS, RESIDUES AND WASTES, GENERAL

7.0001
PRODUCTION OF ALCOHOLS AND OTHER PRODUCTS FROM LIGNOCELLULISTIC BIOMASS USING CHEMICAL PRETREATMENT
Neely WC, Dept. of Chemistry, Auburn University, *Auburn, Alabama, 36830*, (ALA-4-20288)
OBJECTIVE: Determination of optimum operating parameters for pretreatment of lignocellulistic biomass to enable subsequent hydrolysis to fermentable sugars. Development of microbial systems for maximum conversion of pretreated biomass into glucose by enzymatic hydrolysis and subsequently into alcohol and the non-hydrolyzed residue into methane or single cell protein or other economically valuable products. Use of data from all of above research efforts to formulate an economic analysis of the production of alcohol and/or other desired products from lignocellulose using this pretreatment.
APPROACH: Bench scale reactor systems will be tested with regard to effectiveness of conversion as measured by standard testing procedures and with regard to efficiency in terms of ozone consumption. Development of appropriate microbial systems will begin with use of well tested strains such as T virdi for hydrolysis and S cerevisiae for fermentation with major emphasis on conditions optimization rather than new strains. The economic analysis will be conducted concurrently with the experimental work in order to provide maximum guidance for the latter.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0002
ETHANOL AS A SUPPLEMENTAL FUEL FOR AGRICULTURAL DIESEL ENGINES
Walker JT, Dept. of Agricultural Engineering, University of Arkansas, *Fayetteville, Arkansas, 72701*, (ARKF-1023)
OBJECTIVE: Design and apply a secondary fuel system for a diesel tractor engine such that more than 10 percent alcohol by volume may be utilized; evaluate the performance of said system using ethanol in a variety of loads, speeds, and alchol/diesel fuel mass ratios. Operate the tractor in the field and evaluate its performance as a practical system; test other fuels in the system both as secondary fuels and as pilot (injection) fuels.
APPROACH: Develop system; observe laboratory performance-power output, fuel consumption, thermal efficiency, peak cylinder pressure, emissions, operating temperatures; develop field operating procedures--test-evaluate; test other fuels (other alcohols, gasoline, vegetable oils, carb-oils) for use as secondary of pilot (ignition) fuels.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research office.

7.0003
CHARCOAL AS A SINK FOR CARBON IN THE GLOBAL CARBON DIOXIDE CYCLE
Goldberg ED, Scripps Institution of Oceanography University of California, *La Jolla, California, 92038*, (EAR80-17491)
OBJECTIVE: Fossil fuel combustion and biomass burning, especially deforestation and slash/burn agricultural practices, contribute an unknown amount of charcoal to the global carbon cycle. This project will measure the sedimentation rate in five marine cores collected off Panama and Nicaragua and will determine the charcoal accumulation over the past century by using scanning electron microscopy and lead-210 geochronology. The results will be compared with official Panamanian records of burning activities to assess the possibility of using this method to measure the global production of charcoal.
SUPPORTED BY: U.S. National Science Foundation.

7.0004
ECOLOGY OF DESERT ARTHROPODS
Shiff, U.S. Dept. of Energy Lab of Nuclear Med. Radiation Biology, University of California, *Los Angeles, California, 90024*, (000682)
OBJECTIVE: This project is designed to continue an on-going study of desert arthropods with emphasis on those ecosystems which may be influenced by energy associated technologies. The project has now identified a close relationship between a family of phtyophagous insects (membracidae) and the desert shrub larrea. Although this study is currently a part of the STPS environmental monitoring program, the concept and implications are relevant to arid and temperate ecosystems and even the aquatic situation. The close relationship between phytophagous insects and their host plants has the potential of being a sensitive indicator of pollutant movement through the ecosystem. This system could be especially appropriate for monitoring the degree of movement of trace elements which may arise from the burning of fossil fuel or biomass, through the soil to plants and phytophagous insects. That is, it could measure the degree of coupling of energy technologies and food chain incorporation of trace elements. The project feels that studies of plant-insect associations will yield a highly sensitive means of detecting environmental impact and can be widely applicable.
SUPPORTED BY: U.S. Dept. of Energy, Office of Health & Environmental Research.

7.0005
PROCESS ANALYSIS OF THE PHOTOBIOLOGICAL HYDROGEN PRODUCTION SYSTEM
Lindsey H, S R I International, *Menlo Park, California, 94025*, (XK 0 9362 01)
OBJECTIVE: The objective is to prepare preliminary process analyses of the photobiological hydrogen production system that is now being developed at Solar Energy Research Institute (SERI). The purpose is to construct and apply a methodology for assessing options for conversion of wastestream feedstocks to hydrogen using photosynthetic bacteria (PSB). The first task is to define and delineate the candidate unit operations which may be utilized to construct systems for hydrogen production. The analysis of unit operations will be based on consideration of a single feedstock type. (Feedstock characteristics shall be obtained from a separate study.) The candidates will be reviewed to establish those combinations which have potential for being combined into workable systems based on both technical and economic considerations. The second task is to select one system that is envisioned to be workable for detailed process analysis. The process analysis shall include: (1) summary of major process design assumptions and a preliminary design concept; (2) block flowsheet with mass and energy balances; (3) summary of major utility and operating requirements and costs (cost items shall be sufficiently detailed that SERI analysts can perform sensitivity analysis on major capital and production costs items); (4) calculation of process thermal efficiency; (5) plant investment cost estimates (4th quarters 1980 dollars, factored level); and (6) definition and sizing of major equipment items.
SUPPORTED BY: U.S. Dept. of Energy.

7.0006
STUDIES IN BIOENERGY
Unknown, Jet Propulsion Lab, U.S. National Aeronautics & Space Admin., *Pasadena, California, 91103*, (776-91-35)
OBJECTIVE: The objective of this RTOP is to perform the appropriate studies, planning, and technical verification tasks necessary to demonstrate the merit of NASA involvement in bioenergy. The NASA experience and expertise in biomass related technologies will be evaluated to identify, develop, and demonstrate advanced biomass energy delivery systems. The results of this work will provide the recommendations and supportive data necessary to determine the potential for an institutional role in the execution of the national bioenergy program.
APPROACH: The above objectives will be achieved through the following approach with Jet Propulsion Laboratory serving as lead organization and responsible for coordination of the RTOP: (1) focus and refine the emerging biotechnology base and identify NASA center capabilities and roles through the selection and initiation of verification and demonstration tasks; (2) complete the multi-year NASA Bioenergy Plan to identify the potential NASA role and technology focus; and (3) prepare a bioenergy mission analysis, a preliminary implementation plan, and select specific bioenergy delivery systems for further analysis and demonstration in FY-82.
SUPPORTED BY U.S.: National Aeronautics & Space Admin., Jet Propulsion Laboratory.

7.0007
WASTE MATERIAL PROCESSES AND FILES
Stone PL, Fu TT, Navy Civil Engineering Lab, U.S. Dept. of Defense, *Port Hueneme, California, 93043*, (DN687064)
OBJECTIVE: To monitor and evaluate new technology hardware or by-product developments by others and to assess their potential for Navy waste-to-energy implementation or application.
APPROACH: On-site observations or short term tests will be made on operating prototypes such as (1) advanced, higher efficiency (65/+), heat recovery incinerators (HRI/S), and (2) pyrolysis and biological waste-to-energy systems. Storage and combustion tests of a light pyrolytic oil will be made. The concept of firing solid WDF with residual oil will be further evaluated. Transition to 6.3 funding for all above effort by FY83 is planned.
SUPPORTED BY: U.S. Dept. of Defense, Navy.

7.0008
RENEWABLE RESOURCES - ENZYME TECHNOLOGY DIGEST
Sobel H, Neus Inc., *Santa Monica, California, 90406*, (PFR77-12500)
OBJECTIVE: Enzyme technology and renewable resources are two emerging areas of wide application that are interconnected. Enzyme technology refers to the controlled use of enzymes, biological catalysts, which in turn provide us ultimately with renewable resources used for food, fertilizer, building materials, fees, chemicals, and many other useful materials. These two areas are of interest to both the public and private sectors and to several federal agences including the National Science Foundation. The objectives of this grant is to provide for support to create an informal information exchange, the Renewable Resources - Enzyme Technology Digest. The primary objective of this digest is to disseminate pertinent information concerning work in progress at the interface of these two areas. The digest will be produced four (4) times per year and will be available to the general public on a paid subscription basis.
SUPPORTED BY: U.S. National Science Foundation.

7.0009
RESEARCH OF HEAT TREATMENT OF ORGANICS FOR INCREASING ANAEROBIC BIODEGRADIBILITY
Jantzen D, Dept. of Chemistry, Stanford University, *Stanford, California, 94305*, (XR 9 8174 0102)
OBJECTIVE: The objective is to continue research on pretreatment of organic residues in order to develop predictive capability for pretreatment methods. The aim of pretreatment is to convert natural organic materials into less complex substances which are more readily biodegradable by methane-fermenting flora which results in an increase in the yield of methane from a given quantity of material and a reduction in the quantity of residual organics requiring further costly processing and final disposal.
APPROACH: The first approach is biological conversion of lignocellulose, the cell-wall materials in vascular plants which are the most renewable source of chemical energy, to methane. Pretreatment processes will be investigated to determine the best potential for increasing the biological conversion of lignocellulose to methane. The second approach focuses on the examination of the biodegradability of lignin and lignin fractions and its potential for methane production through pretreatment processes. The third approach involves: (1) obtaining an understanding, through thermochemical pretreatment, of why nitrogenous materials are relatively refractory to biodegradation; (2) evaluating the potential of thermochemical treatment for increasing the biodegradability of nitrogenous organics. The fourth approach is to continue biodegradability studies on the methanogenic degradation of a large range of aromatic compounds expected to be released during thermochemical treatment of lignin-containing wastes. The fifth approach is to provide the service of conducting a biochemical methane potential test for evaluating the biodegradability of potential organic residues (BMP) and for determining the presence of materials which are inhibitory to methane microflora (the anaerobic toxicity assay, ATA) to contractors working with methane fermentation.
SUPPORTED BY: U.S. Dept. of Energy.

7.0010
RESEARCH IN PYROLYSIS AND GASIFICATION KINETICS OF DENSIFIED BIOMASS
Kotch A, Dept. of Chemical & Petroleum Refining Engineering, Colorado School of Mines, *Golden, Colorado, 80401*.
OBJECTIVE: The gasification of biomass for the production of fuel gas and clean synthetic gas is of current interest. Because of its low energy density, it has been proposed that an economical way to transport biomass is in densified form. Little is known about the effect of densification on the pyrolysis and gasification kinetics of biomass materials. The purposes of this proposal are to develop a data base for kinetics of densified biomass feedstocks and to use the information to develop a comprehensive kinetic design model which may be used to predict gasifier performance.
SUPPORTED BY: U.S. Dept. of Energy.

7.0011
MARKET DEVELOPMENT/COMMERCIALIZATION
Farley B, Solar Energy Research Inst., *Golden Colorado, 80401*
OBJECTIVE: The overall objective is to provide market and market barrier analysis to assist in commercialization of processes using biomass for energy. The first subtask is to identify the actual industries that have the best potential for further development of biomass use in the industrial and agricultural sectors, particularly non-forest products firms such as brick and textile industries, and dairy and poultry farms. The second subtask is to help identify and reduce institutional barriers that may unduly slow industry's decision to use wood as a fuel, specifically to: (1) identify, monitor and report on emerging governmental incentives in the non-forest industries and other legislation that seeks to stimulate use of wood for industrial fuel; (2) encourage the financial community and potential users to develop and use innovative financial techniques to speed use of biomass; (3) assure that an adequate supply system for wood is being established and analyze new techniques in this area. The third subtask is to provide the DOE Wood Resource Manager with continuous technical and management support for planning, implementing and coordinating the National Wood Commercialization program, as called for in the National Wood Plan. The final subtask is to help promote the use of wastes and residues, primarily wood, as an industrial and residential fuel, placing emphasis particularly on encouraging conversion where users have ready access to or own a waste supply.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0012
MARKET ANALYSIS: BIOMASS MARKET DEVELOPMENT
Farley B, Solar Energy Research Inst., *Golden Colorado, 80401*
OBJECTIVE: The objective is to undertake projects involving near-term commercialization of biomass resources. The commercialization of near-term biomass energy systems, particularly using wood, is dealt with. Four general types of activities are used: (1) seminars for potential users, (at least three such major meetings shall be held); (2) publication of several major reports including one on the use of wood in small industrial facilities (plant managers hand book) and ones on financing options and options for cogeneration under PURPA; (3) a limited amount of technical assistance to near term users and market identification of new users; and (4) program support to the national wood commercialization effort.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0013
FUEL USE ACT RENEWABLE ENERGY STUDY
Farley R, Solar Energy Research Inst., U.S. Dept of Energy, *Golden, Colorado, 80401*
OBJECTIVE: The objective is to determine the criteria to be used by the Economic Regulatory Administration in assessing the feasibility of using various forms of solar energy, including wood, municipal solid waste and agricultural residues in lieu of natural gas or oil as fuel for industrial and utility boilers. The wood task has been completed and published.
SUPPORTED BY: U.S. Dept. of Energy.

7.0014
SYSTEMS ANALYSIS
Finegold J, Solar Energy Research Inst., *Golden, Colorado, 80401*
OBJECTIVE: The objective is to analyze, model, and demonstrate selected systems for producing and utilizing biomass. Research subtasks are to: (1) demonstrate an automobile system consisting of an onboard methanol dissociation reactor and lean burn, high compression engine; (2) rank various biomass alcohol systems for automotive gasoline/alcohol blends considering supply, competing markets, harvest colletion, processing, distribution, and utilization; (3) construct a model of an ocean farm system for growing giant kelp for energy supplies and use this model to evaluate current approaches and suggest alternatives; (4) complete an evaluation of current research in safe, highly efficient, low emissions residential wood stoves, and suggest new design approaches; and (5) perform a systems analysis of multi-fueled 1-2 KW free piston Stirling engine total energy system for developing countries and residential application and suggest a conceptual design. Methodology to be employed for the automotive system includes: literature search, analysis, design, construction, laboratory testing and experimentation, and subcontracts. For the other studies methodology includes literature search, analysis, site inspections, computer modeling, and design.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0015
TECHNICAL EVALUATION, PLANNING, AND MANAGEMENT
Morriss FV, Solar Energy Research Inst., *Golden, Colorado, 80401*
OBJECTIVE: The objective is to provide support to the Alcohol Fuels Program. The tasks include: (1) management; (2) logistic support; (3) planning; (4) research evaluation; (5) preparation of monthly reports; and (6) the Solar Cost Data Bank. The components of this last task are: (1) a determination of the most realistic costs of biomass in a consistent manner on a life-cycle cost basis; (2) an identification of the biomass configurations that are competitive with existing energy alternatives with

respect to cost and schedules; (3) collection of conventional cost data; (4) establishing a range of confidence for biomass cost; and (5) performing economic analysis to determine delivered energy costs for various locations and applications.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0016
RESOURCE ANALYSIS AND ASSESSMENT
Morriss FV, Solar Energy Research Inst., *Golden, Colorado, 80401*
OBJECTIVE: The objective is to use physical and economic tools to measure, analyze, and assess biomass resources and potential resources. The first subtask will involve completion of gasohol policy analysis, interfuel substitution model, and alcohol crops policy analysis. The long-range, multiyear, objective of the second subtask is to develop automatic satellite remote sensing techniques for identifying and mapping biomass energy feedstocks within the US. The third subtask aims to provide an accurate and complete knowledge of the available standing forest biomass energy resource. Objectives of the next subtask are to identify the technically and economically feasible sets of biomass substitution possibilities in petrochemical feedstock markets. The purpose of the final subtask is to quantify the agricultural policy impacts of the American farmer using agricultural waste products as biomass feedstocks.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0017
ADMINISTRATION/SUPPORT
Morriss FV, Solar Energy Research Inst., *Golden, Colorado, 80401*
OBJECTIVE: The objective is to provide administrative services and support for the Solar Energy Research Institute's Biomass Program. Ongoing tasks include management, logistic support, planning, research evaluation, and preparation of reports. An additional task is a portion of the Technology Characterization effort and will be directed by the Systems Analysis branch in FY80 for solar technologies. The Economic Analysis branch will determine annualized costs, focusing on the following items identified by Systems Analysis: (1) a determination of the most realistic costs of biomass in a consistent manner on a life-cycle basis; (2) an identification of the biomass configurations which are competitive with existing energy alternatives with respect to cost and schedules; (3) collection of conventional cost data; (4) establishing a range of confidence for biomass cost; and (5) performing economic analysis to determine delivered energy costs for various locations and applications.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0018
CONVERSION OF LIGNIN TO HIGH-VALUE CHEMICAL INTERMEDIATES
Coughlin RW, Dept. of Chemical Engineering, University of Connecticut, *Storrs, Connecticut, 06268* (PFR80-14523)
OBJECTIVE: Technologies for converting biomass into useful chemicals have been known for decades. Whether the major product sought has been cellulosic fiber or the hydrolysis products of cellulose, lignin has been considered for the most part a by-product. Often, its fate is that of a solid fuel burned to provide process heat in the biomass conversion plant. Future large-scale use of lignocellulose to produce fuels such as alcohols will also produce great quantities of lignin. Processes for large-scale conversion of lignin to high-value liquid chemicals need to be considered in order to achieve optimum and most economical total use of woody biomass. In particular, the studies involve catalytic hydrocracking, shape-selective catalysis, flash hydropyrolysis and hydrogenation by hydrogen-donor solvents for the production of high-value chemical intermediates from lignocellulosic materials. This award is a two-year continuing grant.
SUPPORTED BY: U.S. National Science Foundation.

7.0019
CAPTURING THE SUN THROUGH BIOCONVERSION - CONFERENCE II
Schauffler P, Bio Energy Council, *Washington, District of Columbia, 20006*, (PER77-17117 A02)
OBJECTIVE: This award, a supplement to NSF grant PFR 77-17117 AO1, is for the purpose of providing additional support for the Bio-Energy '80 Conference to be held in Atlanta, Georgia, on April 21-24,1980. Two additional departments, the Department of Agriculture and the Department of Commerce (National Oceanic and Atmospheric Administration), are contributing supplemental support for the conduct of this conference. The supplement does not change the scope or duration of the project. The conference focuses on biomass sources, conversion processes, and products.
SUPPORTED BY: U.S. National Science Foundation.

7.0020
CALORIFIC VALUE OF REFUSE DERIVED FUELS BY BOMB CALORIMETRY
Domalski ES, National Bureau of Standards, U.S. Dept. of Commerce, *Washington, District of Columbia, 20228*, (12204-5433405)
OBJECTIVE: The objective is to develop a constant pressure flow calorimeter capable of burning 2.5 kg of sample of refuse or refuse-developed fuel (RDF) from which a calorific value could be derived. Project scientists consult and work with appropriate committees in ASME and ASTM. Necessary equipment for the kilogram-size calorimeter has been purchased. A 30-ton hydraulic press has been used to prepare a 2.5-kg pellet suitable for testing. A statistical study related to sampling has been carried out and its relevance to the establishment of RDF as an article of commerce will be examined. The thermal correspondence between calorimetric measurements carried out in the calorimeters currently being used or under test (2.5 kg, 25 gm, 1 gm) will be established.
SUPPORTED BY: U.S. Dept. of Energy.

7.0021
ENERGY CONSERVATION AND UTILIZATION IN CITRUS PROCESSING OPERATIONS
Braddock RJ, Kesterson JW, Miller WM, Agricultural Research & Education Center, University of Florida, *Lake Alfred, Florida, 33850*, (FLA-CS-01829)
OBJECTIVE: Develop methods to reduce energy consumption for producing concentrated citrus juices, dried pulp, and molasses. Incorporate energy conservation concept into unit operations, pulp washing, limonene and peel oil recovery, peel leaching, drying, and feed mill stack scrubbing to recover waste energy. Determine energy costs of fruit and product handling, storage, and transportation, apply knowledge to conservation methods. APPROACH: Conduct experiments in the laboratory and pilot plant and apply the results to actual processing plant situations. Primary concerns will be determining energy requirements for unit operations in processing and handling energy and material balance, waste heat recovery, development of new, lower energy consuming processing methods, equipment overdesign and integrate energy cost savings of unit processes with the entire system.
PROGRESS: Using 1979 Florida citrus processing industry production figures and best available technology, the potential alcohol production from component parts of processed citrus fruit was estimated. Gallons of 100% alcohol from each source is as follows: Citrus juice (56,000, 000 gal.), washed pulp (4,200, 000 gal.), water phase essence (152,000gal.), citrus molasses (6,700, 000 gal.), citrus peel sugars (16,000, 000 gal.), and citrus peel cellulose (6,000, 000 gal.) for a total of approximately 90,000,000 gal. Each of these sources is more valuable as a commodity than if converted to fuel alcohol. The bulk density (600 kg/m (3)), volume (1000 cm (3)/kg), area (7000 cm (2)/kg and void space (60% of citrus pellets cattle feed indicate energy advantages compared with bulk loose dried citrus pulp. Savings in energy cost for handling and shipping and storage occur as a result of manufacturing pellets because of a large decrease in volume. Results from a mail questionnaire to Florida citrus packers on energy consumption were computed. Electrical consumption varied from 0.10 to 1.30 KW/carton packed with no apparent relationship to the size of the packinghouse. Overall energy consumption averaged 11.8 MJ/carton packed.
SUPPORTED BY: Florida State Government.

7.0022
POTENTIAL FOR SOLID WASTE RECYCLING AND RECOVERY IN GEORGIA
Brown EE, Dept. of Agricultural Economics, University of Georgia, *Athens, Georgia, 30602*, (GEO00619)
OBJECTIVE: Determination of thé feasibility of resource recovery as an alternative method of solid waste disposal in Georgia. Estimation of current volumes of solid waste generated by each county in Georgia. Estimation of capital and operating costs for resource recovery facilities to handle solid wastes generated. Estimation of capital and operating costs for alternative methods of solid waste disposal, such as sanitary landfill and incineration. Determination of location(s) for resource recovery plant(s). Estimation of transportation costs for the hauling of solid waste materials to recycling facilities. Evaluation of markets for reclaimed resources from solid waste. APPROACH: Working from population data, the types and volumes of solid waste generated will be determined by areas. Then, using a location model, we will determine a location or locations for which transportation costs are minimized. Then by using commercial data on installation costs, fixed and variable operating costs will be synthesized, and the economic feasibility of one or more plants will be determined.
PROGRESS: All necessary data to complete this project was obtained. Objectives were redefined as (1) estimating the content and volume of solid waste in Georgia, (2) estimating costs of operating resource recovery facilities and (3) estimating the benefits of using the combustible portion of the solid waste stream for generating electricity in selected areas as an alternative to landfills. They have been met. It was found that a critical mass of 50,000tons of solid waste was necessary for economical recycling, with a coal using electrical power plant willing to use these solids, must be within 30 miles. Six counties in Georgia would have a potential savings in using solid waste recycling while several more might require a small load subsidy per ton above landfill costs.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0023
MICROBIOLOGY AND PHYSIOLOGY OF ANAEROBIC FERMENTATIONS OF CELLULOSE
Peck HD, Ljungdahl LG, Dept. of Biochemistry, University of Georgia, *Athens, Georgia, 30601*
OBJECTIVE: The microbiology and physiology of individual microbial types involved in the conversion of cellulose to ethanol, acetate, methane, and hydrogen will continue to be investigated. Emphasis will be placed on the physiology of the new bacterium, Thermoanaerobacter ethanolicus, which produces ethanol from a large variety of sugars by means of a yeast-type fermentation at 80 degrees C. Attempts will be continued to modify the organism for greater substrate and ethanol tolerance. The regulatory properties of its alcohol dehydrogenase will continue to be studied with regard to ethanol formation. New thermophilic microorganisms capable of fermenting cellulose to useful products will be isolated and studied from samples obtained from the Icelandic Thermal Springs. Existing programs on the enzymology and bioenergetics of the sulfate reducing bacteria, methanogenic bacteria and homoacetate fermentors will be continued with emphasis on the role of H(2) and hydrogenase in interspecies H(2) transfer. We have observed that cellulose is most rapidly fermented to products when cellulytic microorganisms are grown in association with a second bacterium capable of fermenting cellobiose. These associations will be investigated using thermophilic bacteria with regard to the parameters responsible for successful association and the factors effecting product formation.
SUPPORTED BY: U.S. Dept. of Energy, Office of Energy Research.

7.0024
APPLICATION OF SOLID FUELS BY FLUIDIZED BED COMBUSTION (DA0I8099)
Collishaw A, Construction Engineering Research Lab., U.S. Dept. of Defense, Army Corps of Engineers, *Champaign, Illinois, 61820*, (DAOG5866)
OBJECTIVE: To evaluate and recommend fluidized bed combustion (FBC) technologies firing coal, peat, waste-derived fuel (WDF) and biomass for use at army facilities. Draft etn's for use by district and facilities engineers will be completed containing guidance on planning and design of army coal fired FBC (FY83); maintenance and repair of army coal fired FBC (FY84); planning, design, maintenance and repair of army FBC firing WDF, biomass and peat (FY86). Monitor and evluate work by DOE and industry of fluid bed combustors of army-scale technology. Obtain capital, operating and maintenance cost information on army-scale FBC units.
SUPPORTED BY: U.S. Dept. of Defense, Army, Corps of Engineers.

7.0025
WASTE-DERIVED FUEL (WDF)
Hathaway SA, Construction Engineering Research Lab., U.S. Dept. of Defense, Army Corps of Engineers, *Champaign, Illinois, 61820*, (DAON8137)
OBJECTIVE: To develop design criteria, specification procedures, and performance acceptance evaluation methods for installation-scale technologies for recovering energy from waste and biomass. A technical report will be prepared giving criteria for the design of modular heat recovery incinerator plants and of handling and storage systems for refuse-derived fuel (RDF) (4th qtr - FY79). A technical report will be prepared identifying near-end and long-term installation-scale biomass-derived fuel technologies (1st qtr-FY80). A technical report will be prepared giving criteria for pollution control and boiler design modifications for RDF use. Acceptance testing procedures for modular heat recovery incinerators - and draft engineering instructions for RDF handling and storage system will be prepared (4th qtr - FY80). A technical report will be prepared giving priority application areas for biomass-derived fuel systems (4th qtr-FY81). A technical report giving specification procedures for modular heat recovery incinerators will be prepared- draft guide specifications for production, handlign and combustion of RDF will be furnished- and a technical report giving results of an RDF proof-of-concept field test will be provided (4th wtr - FY81). A draft ETN will be prepared giving planning and implementation guidance for installation-scale biomass-derived fuel system (4th qtr-FY81). Data and information will be collected through parallel efforts of analysis of existing installation-scale EDF and biomass systems, laboratory analysis of combustion phenomena, and comprehensive literature review.
SUPPORTED BY: U.S. Dept. of Defense, Army, Corps of Engineers.

7.0026
EXPANSION OF DIESEL FUEL RESOURCES WITH ETHANOL
Goering CE, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801*, (ILLU-10-0317)
OBJECTIVE: Determine whether low grade diesel can be upgraded to No. 2 diesel fuel by blending with ethanol; determine required concentration of cetane improver in the blended fuel; test the blended fuel in a diesel engine.
APPROACH: Use viscometer to measure viscosity of low grade diesel-ethanol-No. 2 diesel blends and compute heat content of the blends. Use a diesel engine equipped with a gas pressure transducer to measure the ignition delays of several promising blends from step 1. Select the most promising blend for comparative testing against No. 2 diesel fuel in a diesel engine.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0027
DEVELOPMENT OF AN ALCOHOL FUELS PLANT THAT WILL BE ENERGY EFFICIENT AND PROFITABLE
Black HL, Vienna Correctional Center, Southeastern Illinois College, *Vienna, Illinois, 62995*
OBJECTIVE: The objectives are to develop an alcohol fuels training program and tie in existing industrial vocational education programs into the production of food, feed, fiber, fuel and fertilizers. A 4000 square feet building to house the alcohol plant and training station will be constructed. The building will be equipped with experimentation and laboratory equipment so that it serves as a classroom. The program will also install, construct and provide equipment to demonstrate and experiment with new technologies in the alcohol fuels plant. The finished product will be a 500,000gal/yr. anhydrous alcohol plant that will serve as a training center for alcohol fuel production.
SUPPORTED BY: U.S. Dept. of Energy.

7.0028
SCREENING MICROORGANISMS FOR ENERGY CONSERVATION
Eddleman HL, Indiana Biolab, *Palmyra, Indiana, 47164*
OBJECTIVE: The objective of this project is to isolate microorganisms offering advantages in conversion of biomass to ethanol or other hydrocabons or for use as animal feed. The approach will begin with decaying biomass or mutagenized pure cultures and isolated pure cultures or mixed cultures active in conversion of cornstalks or sawdust soluble products suitable for liquid fuel or as feedstocks to replace petroleum-derived compounds. The final product will yield cultures of organisms suitable for further lab scale or pilot plant studies.
SUPPORTED BY: U.S. Dept. of Energy.

7.0029
UTILIZATION OF BIOMASS FOR ENERGY
Barrett JR, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907*, (3302-20190-001)
OBJECTIVE: Develop technology and equipment for using biomass as a renewable energy source. Design equipment and determine operational procedures for direct burning, gasification or pyrolysis of agricultural materials. Analyze potential harvest, transport, and storage systems. Determine availability of biomass as a renewable energy source in the North Central Region. Study energy efficiency in integrated pest management related to increased biomass utilization.
APPROACH: Design, construct and test equipment for analyzing heat and mass transfer during conversion of biomass to direct heat or combustible gas. Design and construct on-farm sized direct-burning, gasification or pyrolysis units. Use test equipment to determine conversion efficiences, and contents of various types of biomass, residue contents, and exhaust gases. Use computerized systems analyses to evaluate materials-handling problems of harvest, transport and storage. Systematically evaluate potential of biomass production in the North Central Region. Use systems analyses and sensitivity analyses to study energy efficiency in integrated pest management by evaluating economic factors and energy consumption with changed technologies such as reduced tillage.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

7.0030
UTILIZATION OF RENEWABLE RESOURCES.
Ladisch MR, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907*, (IND046046)
OBJECTIVE: Study conversion of biomass by biochemical or chemical means into fermentable sugars or chemical intermediates from which oil-sparing fuels and chemicals can be made.
APPROACH: The general approach to be used for this research is to combine wet-bench chemistry with sophisticated analytical techniques including low pressure liquid chromatography (LPLC) and aqueous gel permeation chromatography (GPC) to elucidate basic mechanisms of polysaccharide and lignin breakdown. Scale-up research and development will be carried out in a scale-up facility (pilot plant) located in the Potter building.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0031
CLOSED LOOP HELICAL DISTILLATION APPARATUS
Gahimer DL, Performing Institution Not Reported. *Indiana.*
OBJECTIVE: The objectives of this project are to design and construct a more efficient Mash distillation unit with reduced physical size and material cost. The unit will utilize a Vacuum/Pressure closed loop of inert gas, with automatic control of energy input and Mash flow. Stillage separation will be by centrifugal action. Alcohol fuel economics will be enhanced by a more efficient and less costly distillation process.
SUPPORTED BY: U.S. Dept. of Energy.

7.0032
DEVELOPMENT OF A DRYER FOR STILLAGE
Gerber EW, Performing Institution Not Reported, *Indiana*
OBJECTIVE: The objective is to develop a machine to dry stillage. A tumble action of the stillage with air passing over it will result in drying it. When the stillage is dry it can be stored for safe keeping.
SUPPORTED BY: U.S. Dept. of Energy.

7.0033
BIOMASS HEALTH EFFECTS
Fassel VA, U.S. Dept. of Energy Ames Lab., Iowa State University, *Ames, Iowa, 50010*, (003665)
OBJECTIVE: Toxicities and health effects of emissions, effluents, and residues produced as a result of biomass energy conversions will be studied. Process streams and products will also be evaluated as appropriate. Initial work is concerned with the study of wood-burning systems.
SUPPORTED BY: U.S. Dept. of Energy, Office of Environment.

7.0034
EQUIPMENT FOR RESEARCH ON BIOCONVERSION OF CELLULOSE INTO GLUCOSE AND ALCOHOL
Bassi SD, Dept. of Biology, Benedictine College, *Atchison, Kansas, 66002*, (CDP80-17526)
OBJECTIVE: This award makes it possible to acquire a spectrophotometer, glucose analyzer, and incubator/shaker. In recent years there has been a marked renewal of interest in enzymatic saccharification of cellulose. After evaluating the process, it appears that there are severe technical and economic constraints, including limited availability of suitable substrates; necessity of costly pretreatments of substrates such as corncobs, cornstalks, sawdust, etc; and the high cost of the enzyme obtained from the mold Trichoderma reesei. Yet cellulose is the only renewable resource available in billions of tons annually. The investigator proposes to continue research seeking ways to "coax" Trichoderma into producing a surplus of the enzymes which will produce glucose from cellulose. Much of the research effort will be devoted to optimizing fermentation conditions (pH, temperature, dissolved oxygen, media, combinations of more than one mold) and to inducing mutations by using UV-radiation and selecting for the hypercellulolytic mutants. This research will be significant because the procedures developed will convert cellulose-rich materials to glucose, which will in turn be converted into alcohol and used as automotive fuel.
SUPPORTED BY: U.S. National Science Foundation.

7.0035
INVESTIGATION OF SEPARATION TECHNIQUES FOR ALCOHOL OR GASOHOL PRODUCTION
Kyle BG, Agricultural Experiment Station, Kansas State University, *Manhattan, Kansas, 66502*, (KAN00154)
OBJECTIVE: Investigation of and evaluation of various separation techniques for the production

of alcohol or gasohol and a thermodynamic analysis of the resulting production processes are the objectives of this proposed work.
APPROACH: Phase equilibrium data, where not available in the literature, will be experimentally obtained. These data will be used to perform design studies based on various separation techniques which, in turn, will be used for economic and energetic feasibility studies.
PROGRESS: A process to produce gasohol from fermentation beer without the need to first obtain anhydrous ethanol has been developed. The process uses gasoline as a separating agent and produces gasohol as a product.
SUPPORTED BY: Kansas State Government.

7.0036
ENERGY RELATED TECHNOLOGICAL DEVELOPMENT
Walawender WP, Fan LT, Matthews JC, Dept. of Chemical Engineering, Kansas State University, *Manhattan, Kansas, 66502,* (KAN00946)
OBJECTIVE: This project is directed at development of a continuous pryolysis pilot plant facility for the recovery of useful products from animal wastes. Produce a synthesis gas (composed primarily of CO, H(2), CO(2) and CH(4)) from feedlot manure.
APPROACH: The development involves low pressure flash pyrolysis in a fluidized bed designed to maximize both gas yield and quality.
PROGRESS: The pilot plant fluid-bed gasification facility has been used to gather extensive data over the course of 1979. Over 150 runs were made using cane, manure, sewage sludge and tire rubber as feed materials with gasification temperatures ranging between 1100 and 1450 degrees F. The plant has operated very smoothly for over 200 accumulated hours with all the materials tested. Some representative results for the gas yields (in standard cubic feet of gas per pound of dry ash free feed) and gas heating values (in Btu/cubic foot of gas) follow. With cane, the gas yield ranged from 8 SCF/lb at 1150 degrees F to 21.5 SCF/lb at 1350 degrees F. Gas heating value averaged about 375 Btu/SCF for temperatures between 1100 degrees F and 1350 degrees F. For manure, yields ranged from 4.7 SCF/lb at 1100 degrees F to 16.2 SCF/lb at 1400 degrees F. Heating values averaged about 475 Btu/SCF for temperatures between 1100 degrees F and 1300 degrees F. With tires, yields ranged from 4 SCF/lb at 1200 degrees F to 12.1 SCF/lb at 1450 degrees F. Heating values ranged from 1000 Btu/SCF at 1000 degrees F to 600 Btu/SCF at 1450 degrees F. With sludge the gas yield was about 8 SCF/lb and heating value about 510 Btu/SCF for temperatures between 1300 and 1450 degrees F. The data have been qualitatively analyzed for general trends. Comparative analysis of the data for biomass materials suggests that the level of gas yield can be correlated to the cellulose content of the material.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0037
CHARACTERIZATION OF ENERGY FROM WASTE
Berke JG, National Measurement Lab., U.S. Dept. of Commerce, National Bureau of Standards, *Gaithersburg, Maryland, 20234,* (50610)
OBJECTIVE: To design, develop, construct, and operate a large scale combustion calorimetry facility to carry out research on measurements and other technical needs related to fuels, material properties, environmental problems associated with energy recovery from wastes destined for disposal. To carry out research on material problems such as refractory integrity, lifetimes of grates, particulate emissions, and sampling of wastes and waste products.
SUPPORTED BY: U.S. Dept. of Commerce, National Bureau of Standards.

7.0038
PROCESS OF BIOMETHANATION OF BIOMASS PYROLYSIS GASES
Jantzen D, Dynatech Research & Development Co., *Cambridge, Massachusetts, 02139,* (XB 0 8356 01)
OBJECTIVE: The objective is to apply biomethanation to synthetic gas from gasification plant as alternative route to catalytic methanation for lignocellulosics as raw materials. Tasks include: (1) increase of cell biomass levels from current 1 gm/liter by nutrient optimization under elevated pressure and recycle at mesophyllic and thermophilic temperatures; (2) to determine limiting nutrient, its nature and source in order to increase CO(2)/H(2) methanation productivity and to optimize culture retention time; (3) to establish best medium for processing shift conversion and methanation simultaneously and maximum concentration of CO that does not inhibit action and growth of microorganisms; and (4) to evaluate effects of impurities in synthetic gas on performance of microorganisms applied on fermentation.
SUPPORTED BY: U.S. Dept. of Energy.

7.0039
ENZYMATIC SACCHARIFICATION OF CELLULOSE TO PRODUCE CHEMICALS AND LIQUID FUELS (PHASE I)
Mandels M, Natick Research & Development Command, U.S. Dept. of Defense, Army, *Natick, Massachusetts, 01760,* (DAOH4301)
OBJECTIVE: To carry out laboratory research on cellulase production and saccharification of waste cellulose by cellulase that will lay the foundation and define the parameters for a practical process.
APPROACH: Investigate the physiological, biochemical, and genetic factors involved in induction, synthesis, and secretion of the enzyme. Utilize this information to maximize cellulase yields. Study the interactions of the cellulase enzymes with their substrates, including the effects of levels of the various enzyme components, effects of inhibitors including the products of the reaction, and the effects of cellulose structure, degree of crystallinity, and admixture with impurities such as lingin on the rate and extent of the hydrolysis reaction. Utilize this information to maximize sugar yields.
SUPPORTED BY: U.S. Dept. of Defense, Army.

7.0040
RESEARCH IN GASOHOL PRODUCTION FROM RENEWABLE RESOURCES
Kotch A, Dept. of Chemical Engineering, University of Michigan, *Ann Arbor, Michigan, 48104*
OBJECTIVE: This research will investigate a novel engineering approach to improve the fermentation processes from biomass and other related renewable resources. The intent is to investigate physical and chemical removals of fermentation product during its production as means for alleviating product inhibition and degradation. At the same time, the product is concentrated in a separate phase and facilitates further purification steps by eliminating the traditional filtration and prolonged isolation procedures. For the specific model system, an ultra-filtration-extraction alcohol continuous-fermentation process using gasoline as a separating agent will be investigated.
SUPPORTED BY: U.S. Dept. of Energy.

7.0041
ENERGETIC AND ECONOMIC EVALUATIONS OF MEMBRANE SEPARATIONS FOR ALCOHOL PLANTS
Grulke EA, Dept. of Food Science & Human Nutrition, Michigan State University, *East Lansing, Michigan, 48823,* (MICL03245)
OBJECTIVE: Calculate energy and material balances for ultrafiltration and reverse osmosis separations on ethanol fermentation streams to determine whether positive energy balances are attainable with current technology. Research on the laboratory or pilot-plant scale current membrane technologies to determine separation efficiencies, fouling characteristics, and process energy requirements.
APPROACH: Review literature on separation efficiency and energy requirements for commercial membranes and commercial dialyzer designs. Construct pilot-plant scale dialyzer at ethanol fermentation plant. Determine design strategies and conduct research on separation efficiencies.
SUPPORTED BY: Michigan State Government.

7.0042
BACTERIAL TRANSFORMATION OF LIGNIN
Crawford RL, Freshwater Biological Inst., University of Minnesota, *Novarre, Minnesota, 55392,* (PFR79-06772)
OBJECTIVE: Lignin and cellulose are the two most abundant naturally occurring organic materials on earth and potentially represent important industrial raw materials. Further, as a result of man's increased utilization of these resources, lignocellulosic materials are becoming a major waste disposal problem. The objective of this two-year project is to assess the effectiveness of bacteria for converting lignin in agricultural- and forest-derived lignocellulosic materials to useful products. Specific objectives are to genetically modify lignin-degrading bacteria to produce catabolically blocked mutants, use the blocked mutants to map the catabolic pathways and produce novel lignin-containing compounds. This project is a two-year continuation of NSF grant AER 76-22254.
SUPPORTED BY: U.S. National Science Foundation.

7.0043
ECOLOGY OF METHANE-PRODUCING BACTERIA
Ward DM, Dept. of Microbiology, Montana State University, *Bozeman, Montana, 59715,* (DEB7824070)
OBJECTIVE: The ecology of methane production will be studied in a hot springs environment in which anaerobic decomposition occurs at high temperatures. The objectives include: 1) development of methods for detection of methane-producing bacteria by fluorescence microscopy and autoradiography, 2) analysis of the ecology of methane bacteria and the biochemistry of methane production in nature and 3) the isolation and characterization of methane bacteria native to thermal springs. These studies will contribute to an understanding of the role of these organisms as agents of geochemistry, both past and present, and of their potential for utilization in high temperature systems of organic waste fermentation and methane fuel production.
SUPPORTED BY: U.S. National Science Foundation.

7.0044
ADVANCED WASTE TREATMENT
Cirello J, Manganelli RM, Dept. of Environmental Science, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJ07470)
OBJECTIVE: Investigate the phenomenon of reversible flux decline in cellulose acetate membrane and its relationship to interaction of organic solutes with the membrane. Determine the concentration effect of various organics solutes on the membrane permeability to water. Determine the validity of the Fickian diffusion model for transport through cellulose acetate membranes.
APPROACH: The procedure involves measuring the membrane solute permeability and solvent permeability with several organic solutes in primary and binary solutions. Concentration effects are being looked at and the possible interactions between the solutes and membrane are being investigated.
PROGRESS: Metals in Incinerated Sewage Sludge. Fluidized bed ash had an average median particle size of 28.8u, and a 1 sigma of 7.4 to 145u. Multiple hearth ash had a median diameter of 47.5u and a 1 sigma of 7 to 325u. Preferential concentration of the elements Cu, Cr, Cd, Pb, Ni and Zn occurred with decreasing sludge ash particle size. Field conducted mass balance studies demonstrated that, with the excpetion of mercury, no significant enrichment of trace heavy metals in the off-gas and particulates occurs. Greater than 97 percent of the mercury in the raw sludge can be expected to be emitted to the atmosphere when combustion temperatures exceed 1350 F. The other heavy metals examined -- Cu, Cr, Cd, Pb, Ni, Zn -- emissions were less than one percent of the weight of the amount of metal in the raw sludge. Sludge ash contained 78 to 95 percent, depending on the heavy metal, of the total amount in the raw sludge. Scrubber water accounted for 3 to 20 percent of the total.
SUPPORTED BY: New Jersey State Government.

7.0045
ENERGY AND ENVIRONMENT POLLUTION
Manganelli R, Flower F, Dept. of Environmental Sciences, Rutgers University, *New Brunswick, New Jersey, 08903,* (NJ07490)
OBJECTIVE: Study factors affecting the improvement of combustion and energy conversion relative to formation and change of various pollutants. Evaluate energy conservation and useage in existing, new, and proposed air and wastewater treatment operations.
APPROACH: Procedures will involve laboratory and field investigations in the use of various types of solid and liquid fuels, in method of air and wastewater treatment, in methods of energy balance in treatment and disposal of wastewater and sludges, in methods of combustion of various sludges for energy production.
SUPPORTED BY: New Jersey State Government.

7.0046
BIOMASS THERMAL CONVERSION EXPERIMENTS
Inman B, Dept. of Aerospace & Mechanical Sciences, Princeton University, *Princeton, New Jersey, 08540,* (XB 0 8378 01)
OBJECTIVE: The objectives of this investigation are: (1) to perform experiments using the Setaram DSC to detail the effects of pressure on the heats and rates of pyrolysis in steam and oxygen; (2) to perform experiments using the tubular microreactors to determine the effects of pressure on permanent gas product yields as a function of gas phase temperature and residence time; and (3) to assist in the design and assembly of intense radiation sources for flash pyrolysis research.
SUPPORTED BY: U.S. Dept. of Energy.

7.0047
RESEARCH ON BIOMASS GASIFICATION RATES AND PRODUCTS IN A PRESSURIZED ENVIRONMENT
Inman B, Dept. of Aerospace & Mechanical Sciences, Princeton University, *Princeton, New Jersey, 08540,* (XB 0 9063 01)
OBJECTIVE: The objective is to obtain characterized experimental data, together with attendant mathematical simulation models to describe that data, which can be used to design optimized, efficient, and economical organic waste gasifiers. Research shall emphasize the chemistry of biomass gasification using modest heating rates in a pressurized micro-reactor system.
APPROACH: The first task is the continuation of research to compile a catalogue of the thermal properties of various organic waste and biomass materials which involves: (1) obtaining pyrolytic weight loss versus temperature curves by TGA at various heating rates; (2) obtaining pyrolysis heats of reaction by using DSG; and (3) developing kinetic models to simulate both the weight loss and the heat of pyrolysis data. The second task is to obtain gasification characteristics data for cow manure, corn pellets, oakwood, and Eco Fuel II, using a tubular quartz, plug flow reactor and to develop simulation models capable of predicting the reactor's product state based on reactor conditions. The third task is to use a pressurized tubular reactor experimental system to characterize the effects of pressure on the primary pyrolysis reaction kinetics, and the products and reaction rates of the secondary gas phase reactions. Simulation models shall be developed from the experimental data obtained.
SUPPORTED BY: U.S. Dept. of Energy.

7.0048
ETHANOL PRODUCTION FROM BIOMASS: AVAILABILITY, TECHNICAL AND ECONOMIC FEASIBILITY IN THE NORTHEAST
Kalter RJ, Boisvert RN, Walker L, Dept. of Agricultural Economics, Cornell University, *Ithaca, New York, 14850,* (NYC-121506)
OBJECTIVE: Develop data base on biomass availability for conversion to ethanol in the Northeast. Assess the technical and economic feasibility of ethanol production under alternative feedstock, transportation, scale, joint production, process fuel, capital and operating cost, by-product and product price scenarios. Evaluate alternative public policy initiatives designed to provide incentives for ethanol production.
APPROACH: Data collection will be conducted using standard survey techniques and original source materials. Conventional transportation modeling and Monte Carlo discounted cash flow techniques will be used for the economic analyses based on cost engineering estimates of cost components.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0049
CONTINUOUS TWIN SCREW ACID HYDROLYSIS REACTOR DEVELOPMENT AND OPTIMIZATION FOR ONE-TON DAY WASTE CELLULOSE GLUCOSE PILOT PLANT
Brenner W, Rugg B, Dept. of Applied Science, New York University, *New York, New York, 10012,* (CC2J-C2T903)
OBJECTIVE: Acid hydrolysis of waste cellulose is potentially very attractive because cheap glucose would be a most useful intermediate for chemicals and energy production. Technical problems such as low glucose yields and long reaction times have prevented large scale usage. The purpose of this study, then, is to maximize glucose production from cellulosic wastes using a process of selected pretreatment of cellulosic wastes followed by rapid, high temperture acid hydrolysis.
APPROACH: A 3-year program of experimental investigations is proposed on the additional development and optimization of the continuous twin screw acid hydrolysis reactor for the establishment and operation of a one-ton/day waste cellulose-glucose pilot plant. This program encompasses: (1) the identification of all pertinent acid hydrolysis equipment; (2) procurement and installation; (3) optimization of operating conditions including waste cellulose feed preparation and glucose recovery; (4) product quality analysis; and (5) determination of environmental impact with maximum energy conservation. Initial optimization will be carried out with waste newspapers. The experimental work will be supplemented by a detailed economic cost analysis with subsequent projections for various larger production scale-ups.
PROGRESS: The design and installation of the one-ton/day hydrolysis plant has been completed. Optimization of this facility is ongoing.
SUPPORTED BY: U.S. Environmental Protection Agency. Office of Research and Development.

7.0050
NON-PETROLEUM FUELS FOR POWER UNITS USED BY AGRICULTURE
Kaufman KR, Dept. of Agricultural Engineering, North Dakota State University, *Fargo, North Dakota, 58103,* (ND01437)
OBJECTIVE: Evaluate the use of non-petroleum fuels such as ethyl alcohol, methyl alcohol, and methane for internal combustion engines.
APPROACH: Tractor engines will be tested in the laboratory to determine the effects of substituting alcohol-fuel mixtures for tractor fuel. Both gasoline and diesel engines will be studied. Road tests will be made with automobiles to determine the effects of substituting gasoline-alcohol blends for gasoline. In all tests, comparisons will be made between the energy content of the alcohol-fuel blend and the fuel consumption of the engine. Next, engines will be modified and evaluated for performance and emissions while using alcohol-fuel blends.
PROGRESS: Tests were conducted to determine how alcohol performs in engines. Gasoline and diesel tractor engines and automobiles were tested. The engines were adjusted to factory specifications and all tests were run at these settings. The gasoline tractor engine was and an International Harvester 606. It was connected to a PTO dynamometer and tests were run at partial and full loads. A Ford 8000 was used for the diesel engine tests. It was also connected to a PTO dynamometer. Automobiles tested on the road were 1976 Ford Torinos with 351 cubic inch displacement V-8 engines. Tests were run to compare the benefits of using 190 proof ethanol as compared to 200 proof ethanol in the alcohol-gasoline blends. To achieve a satisfactory mix and one that will not separate out over time it was found that the alcohol portion must be essentially pure (200 proof). Various blends of ethyl alcohol and unleaded gasoline were used in the tractor engines. As the quantity of alcohol blended with the unleaded gasoline was increased, the maximum horsepower which the engine was capable of producing decreased. In addition, the fuel efficiency measured in kw-hr/liter also decreased. Thermal efficiency remained approximately constant. Automobile tests showed that mileage measured in kilometers per liter decreased 3% while using a gasohol blend of 90% unleaded gasoline and 10% ethanol.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0051
GASOHOL UTILIZATION AND TEST PROGRAM
Hurless HD, Bonneville Power Admin., U.S. Dept. of Energy, *Portland, Oregon, 97208*
OBJECTIVE: The objectives are to conserve petroleum-based resources by using transportation fuels derived in part from domestic non-petroleum sources, to demonstrate in a visible way Bonneville's concern for conserving non-renewable resources, and to advance the state-of-the-art for gasohol utilization.
PROGRESS: Five late model sedans are using 10% to 20% methyl alcohol and 80% to 90% unleaded gasoline. Records are maintained on fuel economy, engine performance including exhaust emissions, and maintenance. The vehicles are performing well, and gasoline consumption has been reduced. Approximately 50 additional vehicles are using 10% ethanol and 90% unleaded gasoline. Highly accurate track tests and EPA emission bag tests have been completed, and show slight reduction in fuel economy for the various blends as compared to straight gasoline, and definite savings of gasoline. A large methanol blending/dispensing facility is being installed at Ross Complex, and 10% ethanol blends will be available in many field locations, all scheduled by 31 December 1980.
SUPPORTED BY: U.S. Dept. of Energy.

7.0052
INVESTIGATION OF THE MOLECULAR MECHANISM OF THERMAL TOLERANCE IN BACILLUS SUBTILIS
Ch'ih JJ, Dept. of Biological Chemistry, Hahnemann Medical College & Hospital, *Philadelphia, Pennsylvania, 19102,* (AC02-80ER10703)
OBJECTIVE: In the present work, thermophilic transformants of B. subtilis will be constructed by transformation. B. subtilis will be the recipient, B. caldolyticus will be the donor, and transformation will be carried out by the method of Spizizer according to the procedure described by Lindsay and Creaser. The B. subtilis will be treated with DNA isolated from the thermophile for 4h after which DNase will be added to remove excess DNA. For selecting transformants to grow at high temperature, the treated cells will be allowed to grow at 70 degrees for 18h and then plating for single colonies at 55 degrees. Transformants inheriting streptomycin resistance or adenine prototrophy will be selected. Once a stable thermophilic transformant is isolated, the number of genes responsible for heat stability will be determined and the genes will be mapped. If the proposed work is accomplished, subsequent studies will allow us to focus on the precise mechanism of thermal stabilization in determining the actual site of stabilization whether it occurs during transcription or translation. The understanding of the mechanism is of importance to future industrial application such as fermentation process to produce ethanol and other energy-yielding chemicals from biomass.
SUPPORTED BY: U.S. Dept. of Energy.

7.0053
STRUCTURE AND PROPERTIES OF INDUSTRIAL CARBOHYDRASES
Pazur JH, Dept. of Biochemistry & Biophysics, Pennsylvania State University, *University Park, Pennsylvania, 16802,* (PEN02412)
OBJECTIVE: Obtain information on the moleculr structure and properties of glucoamylase, glucose isomerase, thermostable alpha amylase, and other carbohydrases which may be discovered and which may have potential industrial applications.
APPROACH: Glucoamylase and glucose

isomerase from fungal sources and thermostable alpha amylase from a bacterial source will be purified by chromatography on ion exchange materials. Isozymic forms of the above enzymes if they exist will be prepared and glycoenzymes will be identified. Some of the structural features of the purified enzymes will be determined. Included in the latter will be the carbohydrate types and amount, amino acid composition, and basic nature of the molecular architecture. The role of the carbohydrate units in the stability of the enzyme will be assessed.
PROGRESS: The structural characterization of several enzymes used industrially in the processing of cereal grains has been continued. Analytical methods have been developed for this work and have been tested with compounds of known structure. The initial structural studies have been performed mainly with glucoamylase. This enzyme converts starch to glucose and is used in the manufacture of sweetners from corn and in the production of ethyl alcohol for gasahol. Information on the structure of enxymes can lead to an understanding of the mechanism of action to better methods of using the enzymes. Since glucoamylase has been shown earlier to contain carbohydrate residues, periodate oxidation has been used to investigate the structure of the carbohydrate portion of the enxyme. It was found that periodate did indeed oxidize the carbohydrate units of the enzyme. The oxidized enzyme was highly unstable and precipitated readily from solution. The specific activity of the oxidized enzyme was about the same as the native enzyme. The carbohydrate residues are therefore important in maintaining the stability of the enzyme and are not involved in the activity of the enzyme. In the periodate oxidation reaction hemiacetal bonds can be formed and the possible role for such bonds in maintaining the stability of glucoamylase will be examined.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0054
CYCLING OF HEAVY METALS AND OTHER STABLE ELEMENTS
Smith MH, U.S. Dept. of Energy Savannah River Ecology Lab., University of Georgia, *Aiken, South Carolina, 29801*, (001906)
OBJECTIVE: The purpose of this project is to obtain data on the transport, distribution, and cycling of both stable elements and energy-related contaminants, particularly heavy metals in the environment. Elements of interest include trace metals and macro nutrients important to biomass production in natural systems. Work on trace elements centers around those released in energy conversion processes. Emphasis is placed on the processes by which these elements and polychlorinated biphenols are taken up by the biota. Because of the highly leached soils and soft waters, the southeastern United States may present unique problems for environmental protection. Data on the cycling of these substances and their effects on biological systems will be important in setting and modifying environmental standards relating to energy conversion processes.
SUPPORTED BY: U.S. Dept. of Energy, Office of Health & Environmental Research.

7.0055
NATIONAL ENVIRONMENTAL RESEARCH PARK
Goodson E, Savannah River Ecology Lab., Dept. of Energy, *Aiken, South Carolina, 29801*, (002148)
OBJECTIVE: The National Environmental Research Park (NERP) program of the DOE is designed to provide support for research programs with the goal of minimizing environmental costs of meeting national energy goals. The Savannah River NERP program promotes utilization of the research opportunities on the 300-square mile Savannah River Plant (SRP) site. Studies are conducted at SRP of the long-term effects of coal-fired power plants, industrial cooling water systems, the chemical separation of nuclear fuels, the management of radioactive and nonradioactive hazardous waste, biomass production, and standard forestry practices. The predictive capability developed at SRP is designed so as to be applicable throughout the southeastern coastal plain. As the first NERP, experiences are shared with other sites developing NERP programs directed toward national energy goals. A major effort is being undertaken to develop and disseminate a data bank of baseline environmental information related to research needs at the SRP site. Current baseline studies include providing annotated taxonomic keys and species lists, measuring solar radiation, and mapping and describing wetland ecosytems.
SUPPORTED BY: U.S. Dept. of Energy, Office of Health & Environmental Research.

7.0056
FEASIBILITY STUDY FOR ALTERNATIVE FUEL DEVELOPMENT (SOLID WASTE)
Wood JD, Colleton County Government, *Walterboro, South Carolina, 29488*, (FG01-80RA50373)
OBJECTIVE: The objective of this study is to develop the technical data required to generate an alternate and/or substitute fuel while simultaneously minimizing and/or abating waste disposal problems rapidly occurring for municipalities. Our efforts are directed to smaller (rural) communities that are more seriously handicapped by lack of technical and economical capabilities. The resource to be utilized consists of the chemical change of waste by the action of heat. The product of this distructive distillation is predominantly carbon monoxide and other liberated low Btu gasses. These liberated gases can be cleaned and used to replace natural gas for such things as bake ovens, dryers, etc. Also, air can be added completing the oxidation of the gas which then can be used for steam generation. The final product expected is a report which will determine the economics and technical viability of this process in Colleton County, SC.
SUPPORTED BY: U.S. Dept. of Energy, Office of Energy Research.

7.0057
USE OF NON-ANHYDROUS ETHANOL IN INTERNAL COMBUSTION ENGINES
Chisholm TS, Christianson LL, Dept. of Agricultural Engineering, South Dakota State University, *Brookings, South Dakota, 57006*, (SD00090)
OBJECTIVE: Measure the fuel utilization efficiencies for gasoline engines operated completely on 160 to 190 proof ethanol and for injecting 100 proof ethanol into the incoming air on gasoline and turbocharged diesel engines.
APPROACH: Gasoline engines will be modified to operate completely on 160 to 190 proof ethanol after being started on gasoline. These modification involve heating of the intake air, enlarging the carburetor jets, advancing the spark timing and raising the compression ratio. One-hundred proof ethanol will be injected into the incoming air on gasoline and turbocharged diesel engines. Thorough laboratory, road, and field tests will be carried-out to evaluate the fuel utilization efficiencies associated with these systems.
SUPPORTED BY: South Dakota State Government.

7.0058
ECONOMIC FEASIBILITY AND IMPACTS OF PRODUCING FUEL-GRADE ALCOHOL FROM BIOMASS
Dobbs TL, Dept. of Economics, South Dakota State University, *Brookings, South Dakota, 57006*, (SD00060)
OBJECTIVE: Determine the prospects for small and medium-scale fuel alcohol plants being economically feasible and assess the probable economic impacts of expanded fuel alcohol production on the structure of agriculture and rural economies.
APPROACH: This study will be carried out as part of a multidisciplinary alcohol fuels research effort at SDSU. Most of the technical data required for economic feasibility analyses will come from research to be carried on in other departments at SDSU. Farm management, marketing, and price data will be drawn from various secondary sources.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0059
SYNTHETIC FUELS - ALCOHOLS
Thomas DC, U.S. Tennessee Valley Authority, *Knoxville, Tennessee, 37902*, (TV-50532A)
OBJECTIVES: (1) To follow research, development, demonstration, and production programs related to the manufacture of alcohols from coal, wood, refuse, and other raw materials commercially available in the TVA region; (2) to assess the potential application of alcohols (including fuel blends containing alcohols) to the TVA power system and to regional fuel application; (3) to recommend, where appropriate, TVA participation in research, development, demonstration, and production projects to develop especially promising technologies and applications; (4) to fund research aimed at developing processes to produce alcohol from newspaper and other waste cellulose; and (5) to provide technical support for TVA's Fuels from Biomass Program.
APPROACH: Evaluate research, development, and production progress related to the above technologies and assess the technical and economic feasibility of utilizing alcohol fuels in the TVA power system and in regional fuel applications (including automotive, commercial, home heating, and industrial applications). Consultants may be utilized to accomplish some specific task assigments. Contractors will be used to develop alcohol production processes.
SUPPORTED BY: U.S. Tennessee Valley Authority.

7.0060
ESTIMATION OF REGIONAL LABOR REQUIREMENTS FOR BIOMASS ENERGY SYSTEMS
Ferris G, Manpower Development Division, Oak Ridge Associated Universities, Inc., *Oak Ridge, Tennessee, 37830*, (DE 0 9072 01)
OBJECTIVE: The objective of this contract is to estimate regional labor requirements, by occupation, for selected biomass energy systems. The subcontractor shall conduct field visits and case studies of existing biomass energy systems to derive primary data on the following aspects of biomass systems: production, harvesting/collection, processing, transportation, and biomass end use as a fuel or energy source. Similar data shall be gathered from biomass literature, persons knowledgeable of biomass processes, and industrial experience in industries similar to biomass industries. The study shall make special note of evidence suggesting regional variation in labor or occupational requirements.
SUPPORTED BY: U.S. Dept. of Energy.

7.0061
ASSESSMENT OF POTENTIAL USE OF BIOMASS AS A CHEMICAL SOURCE
Hightower JR, Lee DD, Oak Ridge National Lab., U.S. Dept. of Energy, *Oak Ridge, Tennessee, 37830*, (00026(03)).
OBJECTIVE: The objective of this task is to provide an assessment of the potential for deriving chemical feedstocks from renewable biomass resources. This assessment will contribute to the identification of the energy benefits to the U.S. obtainable from production of such feedstocks in the near- and mid-term, the obstacles to widespread implementation of feedstock production processes, and the potential for removing these obstacles and increasing utilization in the long-term by appropriate development and long-range research. A need exists to develop alternates to organic chemical feedstocks for the chemical industry. In particular, the future supply of petroleum-based chemical feedstocks is uncertain because of the finiteness of domestic petroleum reserves and the instability of foreign supplies. Further, the use of petroleum to provide chemicals requires an equivalent of 7 to 8% of the U.S. energy production, and this is expected to increase in the future. Replacing such materials with biomass-derived feedstocks could provide a significant increase in petroleum availability, and thus, make a positive contribution to energy supply. To determine the potential for producing chemicals from biomass, consideration must be given to biomass availability; potential chemical products, market demand, and competing sources (e.g., coal); current and future process technology; capital, manufacturing, and transportation costs; and the various trade-offs which exist between several options (e.g., direct use of a chemical as a

fuel or as a feedstock). This study will use an interdisciplinary staff from ORNL plus consultants from universities, architect-engineering organizations, and the research and development community. The product of the study will be a definitive document covering the subjects listed above and summarizing anticipated chemical products, factors affecting marketability, and critical needs for research and development.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0062
BIOMASS ENERGY ENVIRONMENT PROJECT
Row TH, McBrayer JF, Roop RD, Oak Ridge National Lab., U.S. Dept. of Energy, *Oak Ridge, Tennessee, 37830,* (W-7405-ENG-26)
OBJECTIVE: Project will supply NEPA-compliance support to the Biomass Energy Systems Division. Support may include preparation of Environmental Impact Statements (EIS's), Environmental Assessments (EA's), handbooks, manuals, and/or topical reports. First priority will be given to responding to BES's needs for preparation of project-specific EA's or EIS's. Additional time available will be devoted to preparation of materials requested by BES which streamline the NEPA compliance process. Our efforts in this mode may include an Environmental Handbook dealing with data collection, environmental monitoring, regulations, permitting, and analysis of alternatives.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0063
ENHANCED PRODUCTION OF ORNAMENTAL PLANTS BY IMPROVED GROWING MEDIA AND GROWTH REGULATOR APPLICATIONS
Emino ER, Dept. of Horticultural Sciences, Texas A & M University, *College Station, Texas, 77843,* (TEX06226)
OBJECTIVE: Evaluate the potential use of by-products such as sludge and other growing media additives as components of growing media for ornamental plants. Emphasis will be placed on rate of application, physical and chemical properties of mediums, nutritional status, heavy metal uptake and problems, cultural system and landscape performance. Also to evaluate exogenous growth regulators in cultural systems of ornamental plants with emphasis on Pyracantha and Quercus, abscission of fruit, flowers, and/or foliage.
APPROACH: Plants will be grown in by-products such as sludge amended media and growth parameters correlated with treatments. The various properties identified under objectives will be determined using standard scientific methods and related to plant growth data. Cultural systems will be devised and tested based on the information obtained. Growth regulators with emphasis on Ethephon will be applied to Pyracantha and Quercus. Plant morphology will be measured and related to cultural systems of the plants. Landscape performance of plants will be correlated with new production systems.
PROGRESS: Interest in growing media research is high among commercial growers and research scientists due to the importance of media in container culture. Also most organic matter amendments are potential environmental pollutants and this offers a valuable use option. Emphasis this year has continued on digested sewage sludge, cedar chips, and rice hull ash. Rice hull ash is a residue from biomass conversion to energy generation. Chrysanthemums grown in sludge exhibited decreasing growth with increasing sludge rates above 40% by vol. With increasing sludge rates water holding capacity increased. Initial pH increased to the 30% sludge rate then stabilized while the pH after 14 weeks reached the pH of the water except in sludge media above 40%. This would indicate high buffering capacity of the sludge. Studies on other properties of sludge amended media are actively underway. Cedar chips look promising for many foliage plants but minor element deficiencies at high rates are a problem. Studies underway are expected to answer questions relating to these deficiencies. Rice hull ash as a vermiculite substitute is promising since plants in 1:1 ash peat were comparable to 1:1 vermiculite-peat in all 3 species treated.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0064
BIOMASS ENERGY SYSTEMS PROGRAM MANAGEMENT ASSISTANCE
Schiefelbein GF, Sealock LJ, Elliott DC, Battelle Pacific Northwest Lab., U.S. Dept. of Energy, *Richland, Washington, 99352,* (AC06-76RL01830)
OBJECTIVE: The purpose of this program is to provide management support to the BES program office in the areas of indirect liquefaction (via synthetic gas), direct combustion and thermochemical conversion by gasification. This management support effort will enable the BES program office to ensure that development activities in these specific areas are carried out in an integrated, well-planned manner with timely completion of goals within budget. The management support to be provided will include: (1) project monitoring and evaluation; (2) program planning and assistance; (3) miscellaneous support activities; (4) in-house program support activities; and (5) reporting.
SUPPORTED BY: U.S. Dept. of Energy, Office of Conservation & Renewable Energy.

7.0065
THE ROLE OF MICROORGANISMS IN WASTE DISPOSAL
Moe PG, Bissonnette GK, Dept. of Plant Sciences, West Virginia University, *Morgantown, West Virginia, 26506,* (WVA00244)
OBJECTIVE: Study Anaerobic digestion for disposal of wastes generated in a family dwelling unit; disposal of effluent and sludge from community sewage disposal plants; generation of methane gas through the anaerobic digestion of animal manures; aerobic composting of manures; soil applications as a waste disposal system for industrial waste materials; disposal of acid mine drainage, and the disposal of industrial wastes in aquatic environments.
APPROACH: Laboratory and field experiments will be conducted of waste applications in aquatic and edaphic ecosystems. Systems will be evaluated for their microbiological populations and biological activity. Environmental factors will be manipulated to estimate optimum conditions for biological activity. Effects of toxicity, synergism and antagonism within the populations will be investigated.
PROGRESS: The microbial population of the bio-oxidation unit of a recycling sanitary waste disposal system was shown to remain remarkably stable in spite of changes in operational and environmental parameters. Fecal coliforms were unable to establish themselves in the indigenous microbial population, indicating that human pathogens would probably not survive in the system either. Gas chromatographic studies indicate that different constituents of a waste oil emulsion vary greatly in their susceptibility to microbial attack in the soil. Certain constituents even demonstrate a temporary increase in concentration, presumably as a result of metabolic transformations. A most-probable-number-fermentation-tube technique has been developed and tested for enumerating populations of methanogenic bacteria in natural sewage sludge samples. The technique is simple to perform and highly reproducible. The addition of the enzyme catalase to selective culture media vastly improved the recovery of sublethally-injured Escherichia coli from environments containing acid mine water. Similarly, incorporation of catalase into standard plate count agar enhanced detection of "total bacteria" from acidic stream environments. Preliminary survival studies, using naturally occurring microbes associated with domestic sewage, has suggested a rapid die-away for sanitary indicator organisms when exposed to acid mine streams.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0066
MICROBIAL ECOLOGY OF METHANOGENESIS
Zeikus JG, Dept. of Bacteriology, University of Wisconsin, *Madison, Wisconsin, 53706,* (DEB7824071)
OBJECTIVE: This work is a part of a continuing study of the ecology and physiology of methane bacteria, and of their role in the carbon cycle of freshwater ecosystems. The studies are centered in Winsconsin lakes (holomictic Lake Mendota and meromictic Knaack Lake). The goals of this research are to 1) describe how the environment controls methanogenesis, 2) define the mechanism of conversion of substrates to methane and the role of electron flow in this process, and 3) determine how methane bacteria interact with other microbial forms in the processes of decomposition and mineralization of organic matter. This knowledge has considerable practical potential for the design of systems of controlled production of methane fuel by fermentation of organic wastes.
SUPPORTED BY: U.S. National Science Foundation.

7.0067
MICROBIAL CHEMICAL AND FUEL PRODUCTION FROM FERMENTATION OF CELLULOSE AND STARCH
Zeikus JG, Dept. of Bacteriology, University of Wisconsin, *Madison, Wisconsin, 53706,* (WIS02376)
OBJECTIVE: Identify the organisms and experimental conditions that are optimal for the microbial conversion of cellulose and starch to ethanol and acetic acid. New species of thermophilic anaerobic saccharolytic bacteria will be isolated and characterized. Cultural parameters optimal for ethanol and acetate production by Clostridium thermocellum will be determined. The catabolic pathway and its regulation will be studied.
APPROACH: The effect of varying cellulose feed rate, source and supply of exogenous growth factors, temperature, pH, etc. on production (yield and rate) of ethanol and acetate by C. thermo-cellum will be studied. Enzymatic studies will determine the catabolic pathway in C. thermocellum and seek to understand how metabolic end product formation is regulated. Bacterial enrichment cultures will be initiated to isolate new species of thermophilic, saccharolytic, anaerobic bacteria that metabolize starch, cellulose and glucose, and that are resistant to high levels of ethanol and acetic acid. Species will be taxonomically identified and the yield of ethanol and acetic acid from energy sources determined.
PROGRESS: The metabolic properties of several thermophilic anaerobic bacteria were investigated to examine their potential in fermenting, cellulose, starch, and wood sugars to ethanol and other products. Cellulose metabolism of C. thermocellum was compared with that of Trichoderma viride and was found to be more active in C. thermocellum. Cellulolytic activity in C. thermocellum was studied by examination of cellulase with a novel continuous, spectrophotometric assay method employing dyed cellulose, and by analysis of oligoglucoside transport. The higher cellulolytic activity in C. thermocellum appears to be related to its unique cellulase and mechanism of oligoglucoside transport. A new starch fermenting-ethanol producing bacterium, Thermoanaerobium brockii was isolated and characterized. The catabolic pathways and regulation of ethanol and end product formation were examined in C. thermocellum and T. Brockii. The results obtained indicate that thermophilic anaerobic bacteria have potential utility in bioconversion of cellulose, starch, and wood sugar to fuels and chemicals. This work was supported by Grants 12-76 and 12-140 from the USDA Forest Service.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

7.0068
DEVICE DEVELOPMENT FOR ETHANOL PRODUCTION ON DAIRY FARMS
Labrenz KL, Performing Institution Not Reported, *Wisconsin*
OBJECTIVE: The purpose of this project is to develop a device for producing ethanol using heat from cooled milk and a vacuum chamber. Since the device is in the development stages, hot water rather than milk will supply the heat source. However, eventually the device should be adaptable for use on dairy farms, with daily production possible at the same time as milking is done.

Summary Information not provided.
SUPPORTED BY: U.S. Dept. of Energy.

7.0069
ALCOHOL AS A FUEL FOR DIESEL FARM AND CONSTRUCTION EQUIPMENT
Unknown, Dept of Mechanical Engineering, University of Wisconsin, *Madison, Wisconsin, 53706*
Summary Information Not Provided.
SUPPORTED BY: U.S. Dept. of Energy.

7.0070
PROCESS DEVELOPMENT UNIT - PDU - FOR PRESSURIZED GASIFICATION OF DOMESTIC FUELS SUCH AS PEAT OR BIOMASS IN STUDSVIK
Rensfelt E, Dept. of Chemistry & Environment, Studsvik Energiteknik AB, *Nykoping, Sweden, S61182 Nykoping,* (53 1760 092)
OBJECTIVE: To design, erect, and operate a 7 tpd Process Development Unit for pressurized gasification of domestic fuel such as peat and biomass to generate a synthetic gas suitable for production of methanol.
APPROACH: The basis of the PDU is a process concept consisting of an oxygen blown pressurized fluid bed gasifier, hot gas dust removal, and conversion of tars and methane in a catalytic secondary stage with oxygen injection. During Phase I (completed) cost estimates and predesign were made. During Phase II (initiated) final design, construction, and erection will be made. Phase III (planned) is a three year period of operation which will be performed during 1983-86. The project is a result of NE 176 010 "PDU-KTH" NE 176 011 "PDU-LTH" and NE 176 025 "PDU-utvardering" dealing with predesign and cost estimates for PDUs and an assessment of feasibility studies of synthetic gas production by oxygen and non-oxygen processes.
PROGRESS: The results and conclusions of the above-mentioned projects, that oxygen blown gasification for synthetic gas production is superior to non-oxygen processes and the advantages of the chosen concept, have been reported in "Projekt PDU", NE/SYNT-80/1. The results of the project will be used to determine the operating conditions best suitable for synthetic gas production, to verify the technical feasibility scale-up. The development of the process may lead to a more efficient process for methanol production from domestic fuels during the nineties.
SUPPORTED BY: Namnden for Energiproduktionforskning.

7.0071
OIL FROM PEAT AND BIOMASS
Bjornbom P, Bjornbom E, Granath L, Kannel A, Karlsson G, Karlsson O, Nilsson T, Ahgren B, Dept. of Chemical Technology, Kungliga Tekniske Hogskolan, *Stockholm, Sweden, S10044 Stockholm 70,* (53 3062 025)
OBJECTIVE: To study different systems of high pressure treatment of peat and biomass for the production of oil using hydrogen and/or carbon monoxide, combined with separation of the water in the peat. Results will be used as a basis for the development of processes for converting peat and biomass into oil.
APPROACH: Exploratory research, mainly experimental, aiming to synthesize and analyze of different process concepts for production from peat/biomass. Stage 1 of the project (research project No. 53 3062 021) included a preliminary technical and economic evaluation. Stages 2, 3, 4 and 5 (No. 53 3062 022 - 025) include experimental work. Stage 2 was carried out in Canada in cooperation with Prof. Chornet at the University of Sherbrooke, Quebec, Canada.
PROGRESS: Results are presented in internal reports of the Department of Chemical Technology, Royal Institute of Technology, S-100 44, Stockholm, Sweden, from where the reports are available. The present stage (stage 5) includes continued exploratory research in batch autoclaves. Furthermore, a continuous bench scale unit (Laboratory Development Unit) will be constructed.
SUPPORTED BY: Namnden for Energiproduktionforskning.

7.0072
ETHANOL PRODUCTION BASED ON LIGNOCELLULOSIC MATERIALS
Edemar L, Rosen C, Eriksson K, Industrial Group, Alfa-Laval AB, *Tumba, Sweden, S14700 Tumba,* (53 1760 301)
OBJECTIVE: Development of process for production of ethanol from lignocellulosic materials.
APPROACH: The project is divided into three stages. The first stage comprises a review and evaluation of the present applicable techniques for the different parts of the process. A preliminary design of the process is made. The selected techniques for the different sections of the process are adapted to each other and further developed in the second stage. The final design of the pilot plant is made. In the third stage a small pilot plant is built and tested. In all stages the technical and economical feasibility of the process will be scrutinized. Producers of alcohol or suppliers of the lignocellulosic feedstock are potential users of developed process. Produced ethanol can be used as fuel, blended with gasoline or as it is, or it can be used as a chemical feedstock. The process utilizes as feedstock cellulosic materials which are domestic Swedish resources. Sweden's reliance on imported energy can be decreased and our balance of trade can be improved. First full-sized industries based on the process are expected to be on line in the second half of the 80's.
SUPPORTED BY: Namnden for Energiproduktionforskning.

8. OTHER NONFOSSIL ENERGY SOURCES

8.0001
WASTE HEAT UTILIZATION - CROP DRYING
Madewell CE, U.S. Tennessee Valley Authority, *Muscle Shoals, Alabama, 35660,* (3071)
OBJECTIVES: The project objectives are to develop, test, and demonstrate commercial application of the use of waste heat for crop drying. Specific objectives include: (1) establish the potential for using waste heat for agricultural crop drying; (2) develop heat exchange and drying systems capable of using waste heat; (3) construct and evaluate a pilot-scale crop drying system using waste heat; and (4) provide technical assistance to potential users. The potential for using waste heat for drying agricultural crops within the TVA region will be assessed. The extent and geographic concentration of conventional drying systems will be determined, as will temperature requirements, heat quantities, and seasonality of drying for major crops that require drying. Heat exchange systems will be selected and evaluated for technical and economical feasibility. A pilot-scale grain drying facility will be constructed and evaluated at an operating power plant. A preliminary assessment has been conducted to establish the extent of crop drying within the TVA region and the type of drying systems offering the greatest potential for waste heat utilization.
SUPPORTED BY: U.S. Tennessee Valley Authority.

8.0002
WASTE HEAT UTILIZATION - GREENHOUSE ENVIRONMENTAL CONTROL
Madewell CE, U.S. Tennessee Valley Authority, *Muscle Shoals, Alabama, 35660,* (3071, 3236)
OBJECTIVE: The project objectives are to develop, test, and demonstrate systems to use waste heat as an alternate heat energy source for greenhouses and to transfer technology and provide technical assistance to commercial users. Technical and economic feasibilities of heating greenhouses with specially designed heat exchangers and low temperature condenser cooling water will be evaluated. Crop production in waste heat greenhouses will be demonstrated. Technical assistance to commercial users will be provided. An experimental direct contact heat exchange system using 70 degrees F water has been shown to be technically feasible in a pilot-scale greenhouse. A 25,000-sq-ft commercial-scale demonstration greenhouse has been operated at the Browns Ferry Nuclear Plant since January 1979. Two heat exchange systems using waste heat are being tested and compared to a conventional heat exchange system. The systems have performed near design expectations, and crops of tomatoes and cucumbers have been successfully grown. Horticultural engineering and economic evaluations are underway to refine the systems and to establish technical and economic feasibilities.
SUPPORTED BY: U.S. Tennessee Valley Authority.

8.0003
ORNAMENTAL PLANT IMPROVEMENT FOR ALASKA
Dinkel DH, Dept. of Plant Physiology, University of Alaska, *Fairbanks, Alaska, 99701,* (ALK34413)
OBJECTIVE: Improve the quality of living in Alaska through the improvement of ornamental plants. Develop propagation techniques for indigenous and hardy exotic ornamental plants, so that a local nursery industry can develop. Provide background knowledge for bedding plant industries and potential cut flower industries.
APPROACH: Native herbaceous and woody plants will be collected and screened for ornamental, ground cover, or landscape potential in Alaska and elsewhere. Screening of exotic ornamentals will be extended, with special emphasis on varieties from other northern areas. Propagation techniques will be developed for use by nurseries for material known to be hardy but which have no known commercial source.
PROGRESS: Seed of selected red clones of natural hybrids of Betula papyrifera and Betula glandulosa gave a segregating population in regards to leaf shape and fall leaf color in seedlings indicating that selection for red fall color could be made in the seedling generation. This will speed the effort to produce ornamental trees with improved red fall color for Alaska. Seedling woody plants that survived the Winter of 1978-1979 were Acer grandidentatum, Acer ginnala, Larix leptolepsis, Larix sibirica, Prunus pennsylvanica, Prunus padus, Prunus mandshurica, Prunus fruiticosa, Pinus sibirica, Pinus mugho, Cornus stolonifera, Spireae beauverdiana, Thuja sp 'Brandon' and Caragana pygmae. Rose cultivars grown in a cool greenhouse with soil heat provided by simulated waste heat were over-wintered in the greenhouse beds at temperatures near 4 degrees C and these plants produced earlier and more commercial quality long stem roses than did bare root plants established in February of that same growing season. These plants produced a lower yield than the 1978 season. Data show that soil heating with water of 38 degrees C could hold air temperature in the single glazed greenhouse at 2-3 degrees C until the outside temperature dropped below -28 degrees C at which time it was necessary to add heat through a perimeter heating system. Market quality of the roses were judged by local florists as outstanding.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

8.0004
TIME AND ENERGY REDUCTIONS FOR FIELD MACHINE OPERATIONS
Hunt DR, Pichai S, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801,* (ILLU-10-0334)
OBJECTIVE: Evaluate a proposal for using the waste heat from a combine engine to preheat harvested grain destined for a dryer.
APPROACH: Make a mathematical model of the process and determine the optimum design parameters for heat transfer to the gain. Design and construct a heat exchange apparatus which will use the heat from a typical combine engine to raise the temperature of the grain in the tank. Test the concept and the design with field studies.
PROGRESS: In an effort to reduce the energy requirements for heated air drying of harvested grain prior to storage, a temperature rise of 10 degrees C was obtained in the grain holding bin of a combine by utilizing waste heat from the engine. Following a mathematical modelling analysis, a heat exchanger was constructed to recover the energy rejected by the engine in the form of hot exhaust gases and by the warm engine coolant. The heat exchanger and a 6.5 m 3/s centrifugal fan was mounted on top of an IH 715 combine with minimal

modification of existing mechanisms. Air flow from the heat exchanger was ducted to the base of the grain bin and escaped to the atmosphere through the accumulated grain. Field tests revealed problems in limiting both engine and grain temperatures. Potentials exist for improved heat transfer efficiencies with a more integrated design.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

8.0005
SURFACE HEATING GREENHOUSES WITH WASTE HEATED WATER
Walker PN, Wells JD, Dept. of Agricultural Engineering, University of Illinois, *Urbana, Illinois, 61801*
OBJECTIVE: This project will help determine the feasibility of heating greenhouses with waste heated water produced at the Baldwin Power Plant.
APPROACH: A commercial-type greenhouse has been constructed next to the power plant cooling lake. Water is being pumped from the power plant discharge canal to the greenhouse where it is distributed over the outside surface of the greenhouse. This technique is called surface-heating and allows the use of much cooler water than could be used with conventional heat exchangers. Note that this heating system does not supply all of the energy required to heat a greenhouse. It does, however, significantly reduce the heat required from conventional sources. The surface heating system will be supplemented with a conventional heating system to maintain a constant 68 degrees F.
The energy and economic efficiency of the system will be measured by operating the surface heating system only every other day. On the other days the greenhouse would be heated using the conventional heating system alone. By comparing the energy use with and without the waste water heating system the energy savings will be demonstrated.
SUPPORTED BY: U.S. Dept. of Energy.

8.0006
STRUCTURAL AND PHOTOCHEMICAL PROPERTIES OF HYDRATED CHLOROPHYLL A AGGREGATES
Fong FK, Dept. of Chemistry, Purdue University, *West Lafayette, Indiana, 47907,* (PCM77-26736)
OBJECTIVE: Preliminary evidence has been obtained that chlorophyll A dimers are capable of photochemically splitting water in vitro, simultaneously evolving hydrogen and oxygen. The ratios of hydrogen: deuterium and oxygen isotope peaks correspond to predictions, and the wavelength dependence of the reaction indicates that chlorophyll is functional. The goal of this project is to scale up the yield of hydrogen and oxygen and to find conditions for sustaining the reaction. If successful, this study would have important implications for energy technology and for understanding photosynthesis in vivo.
SUPPORTED BY: U.S. National Science Foundation.

8.0007
SWINE PRODUCTION FACILITIES USING NO FOSSIL FUEL
Jordan KA, Cornelius SG, Dept. of Agricultural Engineering, University of Minesota, *St. Paul, Minnesota, 55101,* (MIN-12-078)
OBJECTIVE: Develop and verify a mathematical model which adequately predicts the growth and heat production responses of pigs under differing nutritional and environmental influences combined with existing building models, develop swine facility plans which maximize the use of renewable resources and eliminate fossil fuel usage.
APPROACH: Models of swine growth, heat production and critical temperature will be merged to provide a basis for the animal modeling. Groups of weaned pigs will be tested in chambers to verify model. Plans will be developed which utilize conservation, renewable energy sources and heat recovery to provide fossil fuel-free facilities.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

8.0008
A NITROGEN FERTILIZER PRODUCTION SYSTEM FOR FARM USE
Leedy CD, Torell DJ, Lesperance AL, Dept. of Plant Soil & Water Science, University of Nevada, *Reno, Nevada, 89507,* (NEV00450)
OBJECTIVE: Field test a water-powered electric arc nitrogen fertilizer production system (KFPS). Conduct experiments to improve reactor and recovery system design; document the performance of the KFPS in producing fixed nitrogen; demonstrate the impact of the fertilizer on performance of wheat and potatoes and demonstrate capture and use of waste heat.
APPROACH: A water powered KFPS will be installed. Conditions of operation will be varied and results measured. Rate of n trials with wheat and potatoes will be conducted. Waste heat will be collected, sorted in N solution tanks and used to heat a greenhouse.
SUPPORTED BY: Nevada State Government.

8.0009
LOW GRADE WASTE HEAT UTILIZATION (TMP044)
McFadden T, Cold Regions Research & Engineering Lab., U.S. Dept. of Defense, Army Corps of Engineers, *Hanover, New Hampshire, 03755,* (DAOG0867)
OBJECTIVE: The assumption has been that low grade waste heat (70-80 degrees F) can not be cost-effectively utilized. The approach was to analyze and to field test an actual attempt to utilize low grade waste heat. An experiment was designed to evaluate heat transfer characteristics of soil and develop techniques to enhance transfer of heat to soil layers. The experiment was conducted at Ft. Wainwright, Alaska in cooperation with the Univeristy of Alaska. The objective was to determine if agricultural crop growth could be sufficiently enhanced by low grade waste heat to be cost effective.
SUPPORTED. BY: U.S. Dept. of Defense, Army Corps of Engineers.

8.0010
ENERGY CONSERVATION IN COLD STORAGE
Bartsch JA, Blanpied GD, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-1233349)
OBJECTIVE: Determine energy budget for New York State cold storage operations. Determine feasibility of using heat recovery systems operation in same. Evaluate alternate systems for cooling and storing fruit.
APPROACH: Energy use will be monitored for all cold storage equipment in several existing NYS facilities. The factors effecting energy consumption will be identified and savings projected. Refrigerant waste heat recovery units will be monitored and similarly evaluated. Btu savings and value will be computed. Systems using heat exchangers and direct cooling with outside air will be tried with existing apple storage facilities. Effects on fruit quality will be quantified.
SUPPORTED BY: New York State Government.

8.0011
WASTE HEAT GREENHOUSE
Stipanuk DM, Langhans RW, Dept. of Agricultural Engineering, Cornell University, *Ithaca, New York, 14850,* (NYC-123347)
OBJECTIVE: Evaluate the technical and economic feasibility of heating a greenhouse in New York State with waste heat from an electrical generating station.
APPROACH: A greenhouse will be erected on the Cornell Campus. Simulated power plant cooling water will be run through a heat pump to extract heat. This heat will be transferred to water filled plastic bags in the greenhouse. These bags will serve as heat exchangers. Work will be conducted to determine the ability of plants to integrate temperature. The effect on plant growth and yield of varying temperature will be assessed.
RESULTS:
PROGRESS: An air-supported greenhouse of approximately 400 m (2) has been purchased from Environmental Structures Inc. of Cleveland, Ohio. This will serve as the experimental site for future work. Modine Manufacturing of Racine, Wisconsin, has provided a prototype low temperature source heating coil. This coil appears to have lower fan power per unit of energy delivered than do comparable units from other supplies. Experiments will be run to evaluate this. Horticultural work to date has dealt with the use of varying night temperatures and supplemental lighting. Varying night temperature work has confirmed earlier hypothesis that plants integrate night temperature requiring only that the average temperature be the optimum (or normally specified). Work has been done with lettuce and chrysanthemums. Tomatoes and cucumbers have been placed under the supplemental lighting and they exhibit large increases in fruiting compared to the control.
SUPPORTED BY: New York State Government.

8.0012
ENERGY USE AND CONSERVATION IN THE DAIRY INDUSTRY
Jordon WK, Dept. of Food Science, Cornell University, *Ithaca, New York, 14850,* (NYC-143435)
OBJECTIVE: Study the patterns of energy consumption in dairy processing plants. Identify the energy intensive operations. Investigate conservation techniques considering technological, economical and environmental aspects. Develop computer models to study the impacts of proposed conservation techniques. Develop guidelines for the design of energy efficient processing plants.
APPROACH: Monitoring instruments will be installed on the steam, water and electrical services used by the University dairy plant. Data on direct and indirect energy use will be also be collected for about 10 commercial dairy plants in New York State.
PROGRESS: Data from completed studies of energy consumption and losses in food processing in dairy plants in New York State were analysed and the results reported at meetings and in journals. Preliminary data were collected on energy use to operate a walk-in cold room by conventional refrigeration means and by a modified system using cold outside air during winter months. An evaluation of other means of using cold outside air to provide refrigeration in food processing has been initiated.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

8.0013
UNUSED THERMAL ENERGY FROM ELECTRIC POWER GENERATION - TECHNICAL FEASIBILITY
Roller WL, Curry RB, Hamdy MY, Ohio Agricultural Research & Development Center, *Wooster. Ohio, 44691,* (OHO00210-SS)
OBJECTIVE: Study modes of heat transfer for evidence of applicability to the dissipation of heat energy from lukewarm water to agricultural processes. Analytically synthesize combinations of modes into systems which may be evaluated by computer models. Develop pilot model hardware of the system that looks promising in the computer models and test performance experimentally. Make a computer analysis of the economic applicability of the pilot model(s) to the agricultural processes for which suitability appears probable.
APPROACH: Assemble a team of production environment specialists, heat transfer specialist and computer simulation specialists and proceed to attack the problem as indicated in the objectives. Procedure will be updated as facts become available.
PROGRESS: The possible use of power plant waste heat for soil heating in greenhouses is being examined. The first year of this EPRI-sponsored study was completed during the 1978 and served to characterize the physical properties of heat and moisture flow in a diverse set of soils - silt-loam, peat-vermiculite and sand. The heating system being studied consists of 0.025 m pipes, buried in each soil plot at a depth of 0.3 m and spaced 0.3 m apart, that carried heating water at regulated temperatures of 25, 30, 35 and 40 degress C. The irrigation system maintained a water table at a constant depth of 0.5 m. It was determined that sand and silt-loam are approximately equivalent heat conductors and can, for the conditions and heating levels studied, transfer between 19 and 38 watts/m of thermal energy to the greenhouse air. This represents 9 to 18% of the maximum aerial heating load observed for this greenhouse and up to 30% of

the average annual load. The peat-vermiculite figures are, in each case, approximately half of these levels. Some decrease in soil moisture content was observed at the higher heating levels in the region of the heating pipes in the silt-loam and peat-vermiculite soils, but this decrease was not sufficient to pose plant growth problems. Average root-zone soil temperatures ranged between 17 and 32 degrees C. In the second year of the study, the growth of lettuce (variety HR-5) in the heated soil is being studied.
SUPPORTED BY: Ohio State Government.

8.0014
ENERGY RECOVERY FROM DAIRY SYSTEMS
Anderson PM, Kesler EM, Bartlett HD, Dept. of Agricultural Engineering, Pennsylvania State University, *University Park, Pennsylvania, 16802,* (PEN02334)
OBJECTIVE: Develop and evaluate systems for recovering heat from dairy barn ventilation and milking systems.
APPROACH: A heat recovery system using "heat pump" principles will be developed for capturing surfaces will be employed to absorb heat from the ventilation by cooling the air and condensing moisture; captured heat will be transferred through water cooled condensers to a hot water storage tank. Evaporator design will incorporate means to minimize dust fouling and/or to simplify procedures for removing dust accumulation. Following development of operational systems, heat transfer coefficients, net energy recovery, and capital costs will be determined. In addition, heat recovery by the use of newly developed watercooled condensers for milk cooling equipment will be evaluated in relation to energy saving.
PROGRESS: A heat-pump system for recovering heat from dairy housing facilities was installed in a confinement-stall barn at the University Dairy Center. The system consists of a 2-ton water-cooled refrigeration condenser unit and a companion evaporator coil-blower assembly with a 100 liter hot water storage tank. Energy recovery from the system, when barn conditions were 12 degrees C db. and 11 degrees C wb. (85% RH), was 19,000Btu/hr. as heated water, which resulted in a coefficient of performance (COP) of 1.97. Additional insulation will be applied to the system to improve its heat recovery efficiency. The system will be operated for long-term periods during winter 1980 to determine the effect of dust accumulation efficiency. Methods of dust removal will be developed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

8.0015
USE OF THE EARTH AS AN ENERGY SOURCE OR SINK FOR HEATING AND COOLING BUILDINGS
Baxter DO, Dept. of Agricultural Engineering, University of Tennessee, *Knoxville, Tennessee, 37916,* (TEN00587)
OBJECTIVE: Investigate the potential of the earth as an energy source or sink for heating and cooling agricultural buildings.
APPROACH: An airflow system will be designed, developed and installed in an enclosed agricultural building, using the soil as a heat source or sink. A grid of 4- or 6-inch diameter pipes will be buried in the earth, and a fan used for circulating air. Air will be pulled from outside ambient atmosphere, circulated through the underground pipes for heating or cooling, and blown into the building for environmental control.
PROGRESS: Work has consisted of preliminary designs for field installation. Different arrangements for the underground airflow system are being considered. Instrumentation needs are being determined and methods of installation are being developed. Field installation will be performed as soon as designs are completed and the necessary instrumentation and equipment obtained.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

8.0016
WATTS BAR WASTE HEAT PROJECT - BUSINESS DEVELOPMENT
Unknown, U.S. Tennessee Valley Authority, *Knoxville, Tennessee, 37902*
OBJECTIVE: The "Waste Heat Utilization Program" has a subprogram that is designed to assist in company contracts through business development activities in agricultural, aquaculture, and manufacturing industries. The primary objective of this effort is to identify and develop user interest in greenhouse and other potential agriculture applications, aquaculture, and manufacturing applications. Business development activities will lead to "letters of interest" from the company contacts who expressed interest in waste heat utilization and locating at Watts Bar.
APPROACH: The objectives of the subprogram will be achieved through analysis, evaluation of potential applications, identifying, contacting, evaluating for visits, and meeting with potential companies according to the work description developed.
SUPPORTED BY: U.S. Tennessee Valley Authority

8.0017
EFFECTS ON SELECTED ORGANISMS OF WATER PASSING THROUGH THE CEDAR BAYOU GENERATING STATION.
Strawn K, Aldrich DV, Neill WH, Dept. of Wildlife & Fisheries Sciences, Texas A & M University, *College Station, Texas, 77843,* (TEX01869)
OBJECTIVE: Determine the suitability of electric power plant cooling water for growth, food conversion, and survival of selected species of crustaceans and fish in cages, ponds, and temperature-controlled tanks.
APPROACH: Animals will be held in cages in front of the plant intake and in the discharge canal; in fish ponds located near the start of the discharge canal; and in aquaria in a laboratory to be built near the fish ponds. After the construction of the cooling pond, animals will be kept in cages in its first and last compartments and occurrence and distribution of selected organisms in the cooling pond will be determined. Temperatures in the aquaria will span the range of temperatures usually occurring in Trinity Bay. The influence of the effluent on phytoplankters both in the field and in culture will also be determined.
PROGRESS: Information on the relationships between organisms and power plants is needed to permit efficient generation of electricity and protection of the environment. The use of waste heat and pumped water at power plants for the culture of shrimp and fish is not fully understood. Survival of crustaceans and fish taken from the intake screens of the P. H. Robinson Generating Station on Galveston Bay, and placed in cages for a week in the intake canal was lower than that of the same species collected by other means. Fish numbers were low during hot weather both afferent and efferent of the cooling towers on the discharge canal. Evidently fish died in the hot afferent of the cooling towers and did not survive to stock the cooler water downstream. Growth rates of several fish cultured at various temperatures in cages placed in the cooling lake of the Cedar Bayou Generating Station and in a greenhouse laboratory were determined. Growth of brown shrimp increased with an increase in softness of the pond bottom. Fertilization with urea increased the growth rate of white shrimp in 0.1 hectare flow-through ponds. Shrimp concentrated at the inlet and discharge ends of these ponds and were most abundant at the down wind end. A chance experiment indicated that stocking postlarval shrimp at intervals might give better production than stocking all at once. Polyculture of fish and shrimp produced greater growth in fishes than monoculture. Individuals in polyculture ate more food than the same individuals in monoculture.
SUPPORTED BY: Texas State Government.

8.0018
DESIGN OF AN ALCOHOL STILL USING WASTE AUTOMOBILE HEAT
Reinke RG, Performing Institution Not Reported, *Wisconsin,*
OBJECTIVE: The objectives are to design and build an alcohol distillation unit using waste automobile heat and to make the unit completely automatic and self regulating. A distillation unit for mobile use will be built initially working on a semi-auto/manual mode and later optimize to fully automatic mode. The result will be a unit which will be mobile for the average auto, self regulating, automatic, and low cost.
SUPPORTED BY: U.S. Dept. of Energy.

8.0019
SMOKE EATER
Almlof G, Svenska Devel HB, *Linkoping, Sweden, S58220 Linkoping,* (53 5960 161)
OBJECTIVE: To develop the technology and design a pilot plant for a Smoke Eater. This equipment uses the waste energy from flue gases for heating. The Smoke Eater will be designed for gases from fuels with low content of sulfur and high content of water, such as wood chips and lignite.
APPROACH: First step is a market investigation for components which can be used in the Smoke Eater plant. Second step is to make a complete technical specification from some different potential users. After comparing these results with our technical concept, we can state the need for future research and development. Finally, we will make a cost-estimate for a pilot plant including the equipment for using low-temperature heat. The results of this study will show the possibility of using waste energy for heating. The Smoke Eater is especially interesting for greenhouses, storinghouses and other plants, where we can use the low-temperature heat. The fuel savings will be 30-50% for these examples.
SUPPORTED BY: Namnden for Energiproduktionforskning.

9. MULTIPLE ENERGY SOURCES

9.0001
VEGETABLE IMPROVEMENT FOR INTERIOR ALASKA
Dinkel DH, Dept. of Horticulture, University of Alaska, *Fairbanks, Alaska, 99701,* (ALK44418)
OBJECTIVE: Evaluate and select new vegetable cultivars for Interior Alaska for home garden, greenhouse, commercial and processing use. Develop improved nutrition and cultures for new and standard cultivars. Evaluate the climatic and soil factors on growth of vegetables in the greenhouse and outdoor culture.
APPROACH: Vegetable cultivars from the many breeding programs thoughout the world, especially from similar northern latitudes will be evaluated and compared using the best known cultural practices. The soil temperature, soil moisture, and long cool sunlight environment will be studied in relationship to vegetable growth, yield, and quality and to nutritional requirements. Major attention should be given to devising techniques to utilize the vast quantities of geothermal and waste heat energy for the production of vegetable crops in greenhouse, outdoor soil heated areas, and for processing.
PROGRESS: Cool-season vegetables were planted April 24 on soil heated by cooling water from a coal-fired power generation plant compared to April 17 for the previous year. Two successive crops were obtained on most of the cool-season crops; however, some of the later varieties of some crops did not produce two crops on the same plot as in the previous year. A small inexpensive and temporary greenhouse erected on the soil-warmed plots and without other supplemental heat produced 11 kg/m (2) and 5.7 kg/m (2,) respectively, for 'DarkGreen' Cos and 'Ostinata' butterhead lettuce by June 9. Growth of warm-season crops were greatly improved on the warmed soil and further improved with either clear or black polyethylene mulch. Potatoes grown on soil amended with approximately 300 m (3)/ha native peat and fertilized with 1731 kg/ha yielded 2 to 4 times those grown on unamended soil. This is attributed to the contribution of nutrients from the peat source although a similar increase is not usually expected from increased fertilizer applications. The production of warm-season crops such as peppers, melons, tomatoes, and cucumbers were greatly increased

with the use of clear polyethylene mulch with row covers. Potato trials on Delta Clearwater plots yielded Green Mt. 31.8; Kennebec 17.9; Baking 17.9; Rote Erstling 16.1; Emmet 24.2; Alaska 114, 20.7 tons (metric)/ha.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0002
ENERGY IN WESTERN AGRICULTURE -REQUIREMENTS, ADJUSTMENTS, AND ALTERNATIVES
Wade JC, Ayer H, Dept. of Agricultural Economics, University of Arizona, *Tucson, Arizona, 85721*, (ARZT-171562-52-20)
OBJECTIVE: Examine and analyze adjustments which might result from changes in prices and supplies of energy resources, and consequent impacts on Pinal County agriculture. Assess contributions of, and prospects for, alternative technologies and policies for dealings with changes in energy availability.
APPROACH: Linear programming models will developed for representative-farms in Pinal County. Adjustments to changes in prices, supplies, and technologies will be projected using parameteric linear programming techniques.
PROGRESS: Economic assessment of energy problems in Arizona and the Western Region continued with specific interest focused on the conservation and use of water and energy in groundwater pump irrigation systems and in the adoption utilization and management of solar energy in irrigated agriculture. Research which has refined and expanded the farm management models previously utilized to evaluate alternate irrigation technologies has expanded to include more detailed analysis under risk. This expansion of the concept is proceeding as the researchers adjust the modeling concepts to the available data on alternate irrigation systems and the potentials of using solar energy to pump irrigation water. A project entitled "Bayesian Analysis of Irrigation Decision Making for Groundwater Use" was completed in the reporting year. Draft reports are in progress. Inquiries and interest in the economics of using biomass to produce alcohol have grown prompting at least an initial look at these areas.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0003
ENERGY IN WESTERN AGRICULTURE - REQUIREMENTS, ADJUSTMENTS, AND ALTERNATIVES
Williams DW, Larson DL, Dept. of Soils, Water & Engineering, University of Arizona, *Tucson, Arizona, 85721*, (ARZT-171493-51-20)
OBJECTIVE: Assess contributions of, and prospects for, alternative technologies and policies for dealing with changes in energy availability.
APPROACH: An energy balance model (digital computer) will be developed to analyze the energy expended in each of the production operations normally used in Arizona for producing cotton, sorghum, sugar beets, alfalfa, and wheat. Using the model developed above, the energy requirements of alternative technologies will be evaluated, both from the standpoint of total energy and energy derived from each particular energy source (electricity, diesel, natural gas, etc.). Identification of alternative technologies is not a straight forward process, however several general areas show promise for energy savings, including: fertilizer substitutions, alternate irrigation techniques, changes in cultural practices, and improvements in machinery maintenance. The project will evaluate changes in each of these areas.
PROGRESS: The energy used by livestock and poultry operations in the Western U.S. was summarized and compared with the potential for biomass energy recovery from the manure produced by these operations. The same was also done for the major irrigated crops in the Western U.S., comparing crop residue energy potential and solar energy potential with irrigation pumping and crop drying energy requirements. Gasification of crop residues continued and an electrostatic precipitator for cleaning the producer gas was tested. A solar-heated anaerobic digester was constructed and tested. Dairy manure was used to produce methane gas via this digester and it was shown that a simplified, plug flow design works well without any mechanical mixing. The biogas (60% methane, 40% carbon dioxide) was tested in a specially designed burner for cooking, and it was determined that the manure from one cow could produce enough gas daily for the cooking needs of a small family. A dual fuel gas/diesel engine-generator set was purchased and will be tested to determine the feasibility of electrical production from biogas. A spark ignition engine is being modified to burn ethyl alcohol produced from grain and will be tested in comparison with conventional gasoline fuels. Gasohol (10% alcohol, 90% gasoline) will also be tested in this engine.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0004
LANDSCAPE PLANNING AND ENVIRONMENTAL DESIGN FOR ENERGY AND RESOURCE CONSERVATION
Thayer RL, Dept. of Environmental Horticulture, University of California, *Davis, California, 95616*, (CA-D#-EHT-3955-H)
OBJECTIVE: Advance the state-of-the-art in land planning and environmental design in the direction of energy and resource conservation. Contemporary practices of land planning and community design emphasize the automobile, oil-based heating and cooling of buildings, over favoring a planning and design approach that emphasizes mass transit and low-energy circulation systems, renewable and solar energy sources for heating and cooling, and reduced residential water consumption.
APPROACH: Empirical studies which arrive at original data, focused case studies which evaluate new approaches, and original collation, organization and dissemination of advanced methodology for use by planning and design professionals.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0005
PLANT ENVIRONMENT INTERACTIONS
Nobel PS, Dept. of Environmental Biology, University of California, *Los Angeles, California, 90024*, (001915)
OBJECTIVE: The project objective is to develop predictive capabilities for desert plant response to the environment. The data base acquisition and predictive capabilities are being developed simultaneously for different plants within the desert ecosystem. Concern over alternative energy technologies, i.e., solar energy, biohydrocarbon resources, and geothermal, has recently focused extra attention on the utilization of desert resources. Because the desert remains one of the least examined major ecosystems, research on plant-environment interactions is critically needed. Key plant physiological functions and morphological parameters are measured along with environmental aspects affecting the plant in both the laboratory and field. Special emphasis is placed on succulent plants such as cacti, since they figure prominently on threatened or endangered species lists for the desert regions. Water and CO(2) exchange is monitored using assimilation chambers. Laboratory and field studies of plant and environment are combined in comprehensive energy budget analyses to integrate plant and abiotic parameters so that gas fluxes and heat stress can be described in a quantitative manner. The knowledge gained from such basic research can be formulated into models with predictive capabilities. Thus, potential irreversible damage to arid land vegetation can be recognized and energy technologies can be developed in the desert with properly informed management decisions.
SUPPORTED BY: U.S. Dept. of Energy, Office of Health & Environmental Research.

9.0006
LATIN AMERICAN TECHNOLOGY EXCHANGE
Myers LS, Dept. of Radiological Sciences, University of California, *Los Angeles, California, 90024*, (003433)
OBJECTIVE: This proposal is for the development of joint programs between the United States and Latin American countries on common EH and S problems associated with the utilization of energy technologies. Typical of problems that will be addressed are assessment of environmental and socio-economic impacts of central station solar energy development; health and environmental effects of utilization of large heavy oil and tar sand resources; EH and S impacts of large scale use of biomass for energy; and health, social, economic and ecological effects of contamination of air and water by energy technology generated pollutants. The program will be implemented by visits of United States experts to Latin American institutions and work sites where they will investigate EH and S problems and exchange information with their host colleagues, similar visits to the United States by Latin American scientists, workshops to assess and inventory EH and S problems, conferences to exchange scientific information, and working groups to develop recommendations. Results of the program will be fully reported to DOE/ASEV. Members of the LNMRB will review progress, convene meetings for advice and peer review of the program, provide critical summaries, evaluations, and programmatic recommendations regarding EH and S, and develop a management system to serve as a prototype for DOE/ASEV international programs.
SUPPORTED BY: U.S. Dept. of Energy, Office of Environment.

9.0007
ALTERNATE ENERGY SOURCES FOR AGRICULTURAL APPLICATIONS
Hansen RW, Harper JM, Murphy VG, Dept. of Agricultural Engineering, Colorado State University, *Fort Collins, Colorado, 80523*, (COL00064)
OBJECTIVE: Investigate alternate energy sources for agricultural applications. Develop and test a multiple-use solar heat collection, storage, and application system for agricultural uses. Investigate applications of wind energy for agricultural energy needs. Investigate potential fuel production from agricultural waste material.
APPROACH: This project will investigate the possible applications of solar energy to grain drying, livestock building space heating, water heating for dairy use and similar applications. Wind energy will be investigated for potential agricultural applications. Organic waste materials will be investigated as a material for the biological production of fuel gases such as methane, utilizing new techniques to produce biogas.
PROGRESS: Efforts for this reporting period centered around anaerobic fermentation of the fibrous fraction of feedlot waste. This process yields both a methane-rich gas and a protein-rich solid residue. The gas is directly usable as a fuel, and the residue can partially replace soybean meal and other feed supplements, thereby sparing the fuel ordinarily consumed in their production. In one set of experiments, raw feedlot waste fibers were fermented at 50 degrees C and neutral pH for 12 days. This resulted in the production of about 210 liters of gas (roughly 60% methane) per kilogram of fiber. Crude and true protein levels in the final residue were 13% and 25%, respectively, nearly double the amounts in the unfermented fibers. In other experiments, fibers, pretreated with steam at 130-210 degrees C were fermented in a similar manner. This resulted in considerably greater increases in protein (up to 65-70% more than above) but lower yields of methane. Protein production increased and gas production decreased with the severity of the steam treatment. Evidently, caramelization products were formed that inhibited the methanogenic but not the acidogenic bacteria. Future studies will attempt to determine the process parameters that result in the maximum fossil fuel advantage.
SUPPORTED BY: Colorado State Government.

9.0008
ENHANCED CONVERSION OF BIOMASS TO FUELS AND CHEMICALS THROUGH TREATMENT WITH GEOTHERMAL HOT WATER
Murphy VG, Dept. of Agricultural & Chemical Engineering, Colorado State University, *Fort Collins, Colorado, 80523*, (31-1370-3915)
OBJECTIVE: The production of liquid fuels and other organic chemicals from lignocellulosic biomass is in the national interest. To date, however, all approaches to this end have involved energy intensive pretreatments. It is necessary, therefore, that such pretreatments be designed to minimize the consumption of fossil fuel. A modified autohydrolysis process incorporating

direct use of geothermal hot water appears promising in this regard. In one step geothermal water at 120 to 180 degrees C is used to solubilize hemicelluloses and to partially depolymerize lignin. The latter is then extracted into an aqueous ethanol solvent. The remaining cellulose is highly accessible and is therefore readily converted by cellulase enzymes to glucose, which can then be fermented to the desired organic chemicals. The work currently in progress is aimed at determining the optimum solvent extraction procedure for autohydrolyzed wheat straw. The parameters being studied include time, temperature, solvent composition (% ethanol/% water), and solvent/solid ratio. It is expected that the information derived from this work will be directly applicable in the design of a pilot plant demonstrating the production of ethanol from wheat straw and in the estimation of costs for a full scale plant.
SUPPORTED BY: U.S. Dept. of Energy.

9.0009
RESIDENTIAL AND COMMERCIAL SYSTEMS ANALYSIS
Woodley N, Solar Energy Research Inst., *Golden, Colorado, 80401*
OBJECTIVE: The objective is to analyze and respond to various residential and commercial energy needs that can potentially benefit from or use solar energy systems. The tasks are: (1) to study active-air residential solar systems, identifying the costs and problems in developing such a system for mass production (the desired system would provide about one-half of a home's heating needs per year and most of its hot water needs); (2) identifying the cost of a small wind turbine system that could be mass-produced for applications in rural areas and in the residential, commercial, and/or industrial sectors; and (3) to develop comprehensive hybrid analysis techniques, linking both conservation and solar techniques, to produce a method to analyze and optimize energy-efficient systems.
SUPPORTED BY: U.S. Dept. of Energy, Div. of Solar Technology.

9.0010
ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES
Barse J, Zeimetz K, Economic Development Division, U.S. Dept. of Agriculture, Economics & Statistics Service, *Washington, District of Columbia, 20250,* (NRE-43-309-11-00)
OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood and home heating. Analyze the economic feasibility of energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.
APPROACH: Assess the economic resource use and environmental implications of public programs to encourage "energy farms." Develop regional reports on current land and water use, the economic implication for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregional linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empirical studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

9.0011
ASSESSMENT OF TECHNOLOGY IN THE FOOD AND FIBER SYSTEM
Miller ME, National Economic Div., Economics & Statistics Service, U.S. Dept. of Agriculture, *Washington, District of Columbia, 20250,* (NEA-12-107-11-00)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Assessments are made on the feasibility and impacts of new and emerging technology. Use of solar energy is not economically feasible for most applications in agricultural production and processing, but technical progress and changing price relations could significantly improve prospects for feasibility within a decade. Conversion of crop residues to energy products through incinerations, pyrolysis, hydrogasification or fermentation may be feasible in a limited number of specific situation, but widespread adoption by farmers is not now feasible. It is economically feasible to include crop residues in beef cattle growing and maintenance rations, especially if the rations are balanced with grain and supplements. However, the potential for increasing amounts of crop residues fed cattle is limited by the value of leaving the residues on the land for fertility and conservation purposes, costs of collecting, differing geographical concentrations of beef cattle and residues, and other factors. Potential savings of computer-assisted checkout systems in food retail stores are an estimated 1% of gross sales; costs of the systems can be recovered within 3-5 years. A Delphi type of study done cooperatively with the Office of Technology Assessment identifies the emerging technologies in food marketing warranting priority in use of resources for technology assessment. A draft plan for assessing the impacts of agricultural sciences and technologies was completed.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

9.0012
ENERGY REDUCTION FOR ON-FARM PROCESSING OF AGRICULTURAL PRODUCTS
McLendon BD, Rice CE, Cundiff J, Dept. of Agricultural Engineering, University of Georgia, *Athens, Georgia, 30602,* (GEO00700)
OBJECTIVE: Reduce or substitute fossil fuel required in existing systems for processing agricultural crops.
APPROACH: The drying time, product quality, and energy efficiency of drying systems that incorporate solar energy and intermittent air flow into the drying cycle will be evaluated for corn, soybeans, and small grains. A computer model will be used to simulate the drying processes and extend the experimental results. A steel biomass burner system will be designed and constructed to burn forest products and field residues to heat air and water. Combustion efficiency at various levels of draft will be determined and various fuels will be evaluated for their heat output. A simulation optimized control model will be developed to maximize the use of solar energy in a multi-unit tobacco curing system. Supplemental heat will be provided by circulating hot water. The experimental evaluation of the initial test results will require the development of sufficient controls to manage the energy system. The microprocessor based control systems required to operate the drying systems will be developed.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Researcn Office.

9.0013
ENERGY CONVERSION FROM SOLAR TO MECHANICAL POWER
Rice CE, Dept. of Agricultural Engineering, University of Georgia, *Athens, Georgia, 30602,* (GEO00591)
OBJECTIVE: Determine the performance and efficiency of a solar collector - vapor engine system for converting solar energy to mechanical power delivered by a rotating or reciprocating shaft.
APPROACH: A flat plate collector will be used to vaporize Freon 114 and other Freon. The vapor will be used to power a piston engine and an air motor. The vapor will be condensed and the liquid pumped into the collector. Radiation levels, temperatures, pressures, and flow rates will be determined. Engine or motor RPM and torque will be determined for hp calculation. Efficiencies will be calculated. Solar/mechanical system will be field tested as drive system for water pump of solar collector unit.
PROGRESS: A 4-stroke-cycle single engine modified into a 2-stroke-cycle vapor engine. Solar energy collected by a flat plate collector was used to heat "Freon 114" to furnish vapor under pressure to drive the engine. Overall efficiency of 1.3% was obtained. Engine thermal brake efficiency of 3.3%. Feed pump efficiency was 28.8%. Expansion of vapor from 579 kPa to 165 kPa developed 147 watts. A biomass burner system was designed and developed to reduce off hours of direct collection of solar energy. The unit can heat both air and water. Hot water can be used to supply heat to the vapor engine. Thermal efficiency of 73% was obtained with hardwood at a firing rate of 7.2 kg/h.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0014
IMPROVED ENGINEERING TECHNOLOGY FOR PRODUCING POULTRY AND POULTRY PRODUCTS TO CONSERVE ENERGY
Whitehead WK, Shupe WL, Mottola AC, Agricultural Research Center, U.S. Dept. of Agriculture, *Athens, Georgia, 30604,* (7902-20531-002)
OBJECTIVE: Increase poultry industry efficiency through improved or modified processes and equipment to more effectively use, reuse and recover energy.
APPROACH: Reduce energy requirements and costs for various phases and processes of poultry production and processing facilities by developing economical energy recovery and reuse systems and alternate energy sources such as solar and biomass. The efficiency of current operating processes, including heating, cooling, refrigeration, pollution control, materials handling, and transportation will be determined and more economical energy saving techniques will be applied.
PROGRESS: Studies showed that activated sludge treatment could remove 33% of BOD(5), 30% of suspended solids and 50% of oil and grease from poultry processing wastewater at a hydraulic detention of 1 hr. Hydraulic detention of 2 hr and improved suspended solids removal in the clarified effluent could result in a 90% BOD(5) reduction and reduce waste loading of city sewers. Gravity-flow sand filters were tested as a means of further treating poultry processing lagoon effluent to meet proposed EPA regulations. BOD(5) reductions varied from 27-57% and suspended solids were reduced from 37-52%. Effluents from filters with wastewater applied at 0.23 and 0.47 m 3/m 2/day were in compliance with 1983 EPA regulations for BOD(5) and suspended solids during the summer and fall months. Process refrigeration uses 44% and ottal handling and waste treatment 13% of the electricity used in processing plants. Electricity use ranged from 20-24% of the total energy with natural gas and fuel oil providing the remainder. Total electricity requirements can be reduced by properly scheduling the use of large equipment. Hatcheries use 369 MJ of energy/1000 chicks hatched; electricity is 59% of the total. Pelleting accounts for 42% of the total electricity used by broiler feed mills. Total energy is 210 MJ/Mg of feed. Overflow water from the scald tank in a poultry processing plant was used to heat cold replacement water. The 5-plate bank heat exchanger recovered 102 kW in winter and 55 kW in spring and summer.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

9.0015
CONTROL SYSTEMS FOR INTERFACING SOLAR AND BIOMASS FUELS IN AGRICULTURAL DRYERS
Sheppard AP, Butler JL, Graduate School, Georgia Inst. of Technology, *Atlanta, Georgia, 30332*, (7007-20190-019-A)
OBJECTIVE: Design, construct, and test a control unit to interface solar and biomass fuels in crop dryers.
APPROACH: Information on currently available control systems for the burning of alcohol and methane will be gathered and an economic analysis will be made. The analysis will include the relative merits of electronic and pilot light ignition in addition to costs. Based on this information of prototype system will be designed, constructed and evaluated. The feasibility of using a microprocessor to determine the usage of the back-up system, based on such data as air humidity, temperature, solar radiation, and time of day, will be determined. Close liason with other researchers in solar crop drying will be maintained.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

9.0016
DEVELOPMENT OF EQUIPMENT AND PROCEDURES FOR IMPROVED HARVESTING AND PROCESSING SOUTHEASTERN FORAGES
Butler JL, Georgia Coastal Plain Experiment Station, U.S. Dept. of Agriculture, Agricultural Research, *Tifton, Georgia, 31794*, (7702-20190-003)
OBJECTIVE: Develop improved equipment and procedures for producing, harvesting, processing, and storing southeastern forage crops which will reduce the cost and energy requirement and enhance the nutritive quality.
APPROACH: Different machines and methods will be developed which will result in increased stand, with minimum disturbance to the sod, of seasonal annual forage crops overseeded on perennial sod crops. New machanisms will be developed to cut and prepare forage crops for field wilting. These will position the forage crop to take maximum advantage of solar, wind, and other sources of energy. Processing and storage methods will be evaluated on the basis of energy requirements and effectiveness in converting forage into meat and milk. This work will be cooperative with plant and animal scientists, both state and federal.
PROGRESS: Arrowleaf clover was ensiled with and without the addition of a mixture of propionic acid and formaldehyde (Chemstor III) at the rate of 1.1 percent of dry matter. The treated silage had lower fermentation temperatures and no seepage. Dairy heifers fed the treated silage consumned four percent more silage dry matter per day, gained 20% more per day and ate only 87% as much feed per pound of gain as those fed untreated silage. Monesin sodium was pelleted with Coastal bermudagrass at the rate of 33/m ppm using a specially designed additive hopper. Calves fed the additive gained 12% faster (p less than .05) than the control. Arrowleaf clover overseeded on Coastal bermudagrass sod yielded 1.7 tons d.m. clover and 4.2 tons d.m. Coastal bermudagrass per acre. The yield was considered to be reduced by the dry weather.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

9.0017
DEVELOPMENT OF SYSTEMS FOR UTILIZING SOLAR AND BIOMASS ENERGY TO MAKE FARMS ENERGY SELF-SUFFICIENT
Butler JL, Georgia Coastal Plain Experiment Station, U.S. Dept. of Agriculture, Agricultural Research, *Tifton, Georgia, 31794*, (7702-20195-001)
OBJECTIVE: Develop methods, equipment and procedures to harvest, process, store, and utilize solar energy, crop residues, and specifically produced crops to make agriculture energy self-sufficient.
APPROACH: The energy potential for various crops (including woody and aquatic) and crop residues will be evaluated and energy efficient methods and machines to harvest the most promising crops and/or residues will be developed. Systems will then be developed for processing, handling and storing this biomass for use in on-farm conversion into more desirable forms of energy. Systems to efficently collect, store and utilize solar energy for crop drying and other agricultural applications such as heating and cooling will be developed. These systems will include the necessary equipment and controls to interface with other forms of alternate energy.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

9.0018
MOLD PREVENTION WITH ENERGY CONSERVATION DURING HARVESTING AND CURING PEANUTS IN THE SOUTHEAST
Troeger JM, Georgia Coastal Plain Experiment Station, U.S. Dept. of Agriculture, Agricultural Research, *Tifton, Georgia, 31794*, (7702-20190-001)
OBJECTIVE: Develop equipment and procedures for harvesting, curing, and storing peanuts to minimize mycotoxin and mold contamination, and maintain maximum quality with a minimum expenditure of fossil fuel energy.
APPROACH: Determine harvesting and curing procedures that will maintain maximum quality of peanuts by minimizing mold and mycotoxin contamination. Determine procedures which will make maximum use of solar, wind, and other sources of energy which will decrease dependence on fossil fuel energy and maintain maximum quality. Laboratory controlled experiments will be used to determine limiting conditions. These parameters will then be applied to production quantities. Equipment and recommended practices will be developed and made available to the peanut producer.
PROGRESS: Tests were conducted to determine the effects of interrupting airflow (and heat), during peanut drying, on energy consumption, drying time and peanut quality. Interrupt patterns included 15, 30, and 45 minutes off per hour and one hour off in four. Airflow rates of 13 and 25 cubic meters/min/cubic meter of peanuts were used. Initial moisture content of the peanuts ranged from 16 to 23% moisture. Final moisture content was 20% Drying time was not significantly increased by interrupting for 15 minutes per hour or one hour in four, but interrupting for 30 minutes per hour and 45 minutes per hour or one hour in four, but interrupting for 30 minutes per hour and 45 minutes per hour increased drying time by 24% and 62% respectively. Percentage of sound splits, a measure of quality, was not significantly different among treatments and all were below 4%. The difference in final moisture content between bottom and top of the bin was significantly less for the high air flow rate.
SUPPORTED BY: U.S. Dept of Agriculture, Agricultural Research.

9.0019
SOLAR PAPAYA DRYING AND WASTE CONVERSION
Livingstone DJ, La Maloo Dried Fruit, *Pahoa, Hawaii, 96778*
OBJECTIVE: This project involves demonstrating an integrated system using solar energy to convert wasted papaya into usable food (dried fruit). The system consists of three phases: (1) solar dehydration of usable fruit; (2) solar distillation of unusable portions of fruit to produce alcohol fuel to continue the drying operation on cloudy days, (low solar radiation); and (3) reclamation of marginal land with composted fruit wastes and spent mash.
SUPPORTED BY: U.S. Dept. of Energy.

9.0020
ECONOMIC ANALYSIS OF RESOUCE POLICY ISSUES IN AGRICULTURE
Tyner WE, Dept. of Agricultural Economics, Purdue University, *West Lafayette, Indiana, 47907*, (IND045076)
OBJECTIVE: Estimate the efficiency of alternative leasing policies in achieving government objectives for resource disposition, estimate the efficiency and equity impacts of tax and regulatory policies for energy sources with emphasis on the agricultural sector, determine price and usage conditions for solar energy with capital sharing for farm and rural residential applications, and estimate the impacts of resource policies in developing countries with emphasis on the indrict impact of such policies on American agriculture.
APPROACH: The priniciples of welfare theory and public finance and various quantitative methods will be used to estimate impacts of alternative resource policies in agriculture. Monte Carlo simulation and game theory will be used to handle uncertainty. Capital budgeting and investment analysis will be used to compare energy consumption alternatives. Cost-benefit analysis will be used for evaluation of resource investments.
PROGRESS: Research in 1979 was concentrated on energy from biomass. Much of my time was spent in estimating the potential of producing energy (primarily alcohol) from agriculture. We estimated the potential alcohol production from crop residues, grains and forage crops. The total potential ranged from 45 to 74 billion liters of alcohol per year which is 10 to 16% of our current gasoline consumption. Realizable production may be considerably less than this range. Research on the policy implications of energy production from agriculture also was undertaken this year. If energy production from agriculture is added to the list of objectives of U.S. farm policy, we need to rethink much of current agricultural policy. Grain reserve policy, food aid policy and farm program management are all areas in which current policy will be reconsidered. Another research area was the comparison of energy production potential from agriculture with the technical and economic potential for liquid fuels production from coal, oil shale and enhanced oil recovery. In this connection, we examined the approaches which could be used to solve our energy liquids problem and the policy altenatives which could be used to achieve our national energy objectives. Finally, research is underway on the economic of solar hybrid passive/active systems and the interaction of peak load electricity pricing with the economics of solar energy.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0021
DRYING, HANDLING & STORAGE OF GRAIN CROPS
Foster GH, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907*, (IND046039)
OBJECTIVE: Improve post-harvest conditioning, handling, and storage of grain crops through reduced damage, lowered cost, reduced energy requirements and development of alternate energy sources.
APPROACH: Various combinations of high temperature drying and in-storage low temperature drying, the latter utilizing both natural and solar heated air, will be evaluated in terms of grain quality maintenance and energy use efficiency. Optimum moisture levels for each phase of the process will be determined, considering weather and crop conditions. Methods and equipment for reducing velocity and impact damage of grain from gravity spouts will be designed, tested and evaluated. As an energy conservation measure, a heat pump will be tested for low temperature grain drying and for higher temperature operation with recirculation of the drying air. Solar energy and utilization of biomass- mainly crop residues - will be studied as alternate energy sources for grain drying.
PROGRESS: Corn harvested at moistures from 24 to 30% was successfully dried in a low temperature, layer drying system using solar energy. About 75 square meters of collector provided a temperature rise in the drying air of about 4 degrees C. The corn was dried to 16% moisture in 28 days and demonstrated that solar energy, properly applied, can dry corn from typical field-harvest moisture levels. A low temperature heat pump grain drying system was tested and compared with an electric resistance heat dryer. Weather was colder than during the previous year's test and the heat pump operated in the closed mode more of the time. The energy savings, compared to resistance heat, was 31%. Using heat from gas generated from 820 kg of cobs in a gasifier, a batch of 12.7 tonnes of corn was dried from 23 to 13% moisture content. The cobs used were one-third those available from the corn dried. Twelve methods or devices for reducing impact damage to grain discharged from gravity spouts were tested. Devices that gradually reduce grain velocity were effective and reduced the breakage of corn that leads to market discounts by up to 75%.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0022
DRYING GRAIN WITH HEAT FROM CROP RESIDUES AND SOLAR ENERGY
Foster GH, Hartsock JG, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (3090-20593-032-A)
OBJECTIVE: Develop, evaluate and demonstrate a farm grain drying system using heat from renewable resources by testing a combination high-temperature/low-temperature drying system using crop residues as a fuel for the high-temperature phase and solar energy for the low-temperature phase.
APPROACH: Develop a non-fossil fuel drying system that will handle approximately 500 bushels of 25% moisture corn daily, regardless of weather. Determine airflow and solar heat requirements and demonstrate the use of solar energy for drying corn in storage bins filled by layers with either freshly harvested corn or partially dried corn from a high temperature batch dryer. Evaluate quality characteristics of corn dried. Develop combustion methods for extracting stored solar heat from corn cobs and related crop residues, including: equipment and methods for mechanically introducing cobs into the combustion device; controls necessary to assure adequate and safe operation of the dryer using crop residues as a fuel.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

9.0023
ENERGY EFFECTS IN CROP-ENVIRONMENT INTERACTIONS
Peart RM, Dept. of Agricultural Engineering, Purdue University, *West Lafayette, Indiana, 47907,* (IND046021)
OBJECTIVE: Determine the effects of energy inputs such as solar radiation, fertilizers, tillage cultivation, harvest, pesticides, and artificial drying methods on the quantity and quality of major Indiana crops including corn, soybeans, alfalfa, and wheat.
APPROACH: Develop mathematical models of specific processes for simulation studies using environmental data and energy source data as inputs. These simulations can be re-run quickly and economically using historical weather data and varying energy inputs. These results may then be evaluated on the basis of effects on food production, economic returns, energy consumption or energy input/output ratios. A major application will be grain drying with various combinations of solar energy, gas fuel, and electricity. Crop ecosystem simulation work will also be continued to better advise farmers on alfalfa management. Alfalfa drying using solar energy needs research. Weather data is available, an excellent alfalfa growth simulator, SIMED, has just been developed and solar drying of corn is being studied, so the alfalfa drying work could follow naturally. Studies of energy effects on total agricultural production will also be started.
PROGRESS: The Fuel Estimator program was modified and used again to project statewide timing and amount of gas fuel demand for corn drying. A statewide LP gas distributor again cooperated in this work and provided feedback as to actual LP gas usage compared to the program projections. The program is very useful and is considered to be operational now with no further modifications. Further operating tests were made of the cob gasifier, and a burner-heat exchanger was designed and installed. A 5-hp centrifugal fan supplies about 5000 cfm of air through the cob gas burner for direct heating of this air by the gas flame. Five hundred bushels of corn were dried from 23% to 13% moisture with the gasifier unit using 1800 pounds of cobs of about 10% moisture. Cooperation was continued with an interdisciplinary group studying energy relations in agriculture. More emphasis was placed on alcohol production from corn grain and from crop residues. Controversy over the net energy balance for ethanol from corn was strong in 1979. We show in one analysis that one acre of 140-bushel corn grain can result in a net liquid fuel output of 250 gal. of ethanol after deducting from the ethanol output all o (Text Truncated - Exceeds Capacity)
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0024
DEVELOPMENT OF MATERIAL AND ENERGY BALANCE REGULARITIES FOR RENEWABLE ENERGY RESOURCES
Bull SR, Dept. of Chemical Engineering, Kansas State University, *Manhattan, Kansas, 66502*
OBJECTIVE: The purpose is to develop and use material and energy balance regularities in the analysis of chemical and biochemical processes associated with the utilization of solar energy. The general goal of this research is the identification and use of similar regularities in the analysis of processes associated with the conversion of solar energy to renewable chemical energy resources (crops) and the conversion and utilization of these resources. The production of agricultural crops and forests, the conversion of solid renewable energy resources (wood, crops, crop residues, and leaves) to useful fuels via gasification (pyrolysis and combustion), and anaerobic digestion of solid fuels, and the microbial conversion of carbohydrates to more useful energy forms such as ethanol will be investigated using regularities.
SUPPORTED BY: U.S. Dept. of Energy.

9.0025
ENERGY REDUCTION FOR ON-FARM PROCESSING OF AGRICULTURAL PRODUCST
Parker BF, Loewer OJ, Pagoulatos A, Dept. of Agricultural Engineering, University of Kentucky, *Lexington, Kentucky, 40506,* (KY01051)
OBJECTIVE: Determine energy consumption of various harvesting, processing, and storage systems. Reduce or substitute for fossil fuel required in existing systems for processing agricultural crops. Perform an economic analysis of new and existing processing systems.
APPROACH: The overall performance efficiency and the effectiveness of energy use for different combinations of grain harvesting, delivery, drying, and storage system components will be evaluated using computer simulation techniques. A high temperature grain drying system using concentrating collectors and rock-bed energy-storage units will be constructed and tested. The conversion of crop residues into thermal energy for crop drying using a biomass gasification combustion process will also be studied. A full-scale demonstration model will be built. Using the results of other investigators along with information from census reports and cooperative crop reporting services, economic optimum methods and systems for harvesting and processing relevant crops will be determined for various types of farms.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0026
SOLAR ENERGY COLLECTION AND BIOMASS GASIFICATION FOR ENVIRONMENTAL MODIFICATION OF LIVESTOCK SHELTERS
Parker BF, Winter DW, Dept. of Engineering, University of Kentucky, *Lexington, Kentucky, 40506,* (7005-20400-017-A)
OBJECTIVE: Develop an integrated, multiple-use energy system to heat air for animal structures and for high temperature grain drying using solar-thermal and biomass gasification as energy sources with a rock bed heat storage.
APPROACH: Finalize design of solar collector and rock bed system based upon performance test of the solar collector in both modes of operation and upon results of tests using crushed limestone as a heat storage medium. Construct and test biomass gasifer. Optimize system for heating the swine building and for grain drying.
PROGRESS: The work during the initial six months of this project centered on the design, development, construction and testing of a dual temperature solar air heater. In concept, the higher temperature level would be most usable for storing heat and the lower temperature level for higher airflows and direct use of the heat in the animal structure during moderate weather. The design developed includes a vee corrugated absorber plate with flow only underneath the plate for use as a high temperature unit and then opening a port to allow flow on both sides of the plate with double the airflow rate for the low temperature operation. The unit has been designed and constructed and is currently under test.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

9.0027
ALTERNATE SOURCES OF HEAT ENERGY FOR RURAL MAINE
Smith N, Huff E, Riley J, Dept. of Agricultural Engineering, University of Maine, *Orono, Maine, 04469,* (ME08104)
OBJECTIVE: Evaluate the feasibility of new sources of heat energy for domestic, agricultural, and industrial use in rural Maine.
APPROACH: The solar assisted heat pumps now in operation will be monitored and developed further. The wood chip furnaces now in operation and being designed will be monitored and developed further. Small solid waste burners and batch loaded wood furnaces will be developed using the dual combustion principle being developed for broiler litter. Techniques for large scale harvesting and handling of logging residues and wood fuel produced in short rotation systems will be developed. Other energy sources with possibilities for rural Maine will be evaluated, e.g., peat bogs, bark piles, right of way clearances, etc.
PROGRESS: The institutional size wood chip furnaces heating a factory and a school in Maine have continued in operation. A miniaturized firebox and automatic control system was tested during spring and summer. Firing rates from 50,000-100,000Btu/hour were tested. Two units are now being tested in homes with preliminary approval from the Maine Oil Burner Licensing Board. Both units are firing existing furnaces, replacing the original oil burner that is used as an igniter for the chips. A litter burning furnace to heat poultry houses is being built under a grant from the Maine Poultry Federation. Flame extinction and total burning times were measured for 3 sizes and 3 moisture contents of pine wood cubes burned at 3 furnace wall temperatures and 3 air temperatures. Burning time increased with size and with moisture content, and decreased as well-defined non-linear equations. Air temperature had no significant effect on total burning time. A burning time prediction equation was developed which points the way to quantifying combustion intensity in furnaces. Knowing the effects of parameters on burning time should enable combustion intensity to be increased and fireboxes made smaller for faster response on cold starts. An air: air solar assisted heat pump system using 300 ft. 2 of collectors to supply heat for an 800 ft.(2) office building was evaluated. Overall C.O.P. for the calendar year 1979 was approximately 3.0. A similar system heating a house in Waterville, Maine, attained a C.O.P. of 4.5.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0028
ENGINEERING ASPECTS OF PROCESSING AGRICULTURAL PRODUCTS
Brook RC, Dept. of Agricultural Engineering, Michigan State University, *East Lansing, Michigan, 48823,* (MICL00724)
OBJECTIVE: Make pea beans less susceptible to cracking damage during shipment; cool sugar beets from 60 degrees F to 40 degrees F in the most economical way.
APPROACH: A deep bed of pea beans will be treated with conditioned air to increase bean moisture content and thus make beans less susceptible to cracking damage during shipment. Tests will be extended to wider airflow rates and a larger range of temperature conditions. A recent pure-air-conditioning unit will be used. A newly developed mathematical theory will be employed to analyze data. Sugar beets will be artificial cooled in three separate experimental test facilities. The experimental setups include: a 4' x 4' x 10' box holding 2 tons of sugar beets for aircooling; a 1 1/2 x 2' x 6' immersion type hydrocooler for cooling 200 pounds of sugar beets; and an evaporative spray-type combination air-water cooler for cooling individual sugar beets.
PROGRESS: Mathematical models for the storage environment of bulk stored agricultural products have been developed. The model has been validated for potatoes and used to evaluate ventilation rates and schedules. Alternative energy sources for reducing fossil fuel energy consumption during drying of grains were investigated.

Energy sources investigated included biomass (by gasification and direct combustion), solar energy, and electricity. The alternative sources are technically feasible, but economic and management questions have yet to be answered.
SUPPORTED BY: Michigan State Government.

9.0029
ENERGY AND AGRICULTURE
Stout BA, Dept. of Agricultural Engineering, Michigan State University, *East Lansing, Michigan, 48823,* (MICL01208)
OBJECTIVE: Find ways to beneficially use waste heat from electric power plants in agriculture. The uniqueness of the MSU research does not lie in the subject of the study, but in the approach. Rather than considering the utilization of waste heat in one or two agricultural processes on an experimental basis, the feasibility of an integrated system of a significant number of subsystems is being examined by systems analysis techniques. The result of this research effort should be an analytical tool that can be used to analyze the feasibility of using waste heat from power plants in agriculture.
APPROACH: An optimization technique for determining the best combination of agricultural subsystems for a power plant is being developed. The program has already been used to determine the effect of weather conditions on the best mix of a power plant-fish pond-soil pipe system. During the second year of the project additional subsystems will be modeled and economically investigated. Greenhouse culture, waste treatment and grain drying offer possibilities. Ownership options and financing schemes have to be considered along with the transportation of the waste heat from the power plant to the different subsystems.
PROGRESS: Energy audit study of production agriculture in Michigan looking at diesel fuel, gasoline, natural gas, propane, electricity, fertilizers, and chemicals. Feasibility study of solar water heating in food processing plants in the Midwestern United States; testing of a pilot scale system and planning of a demonstration project. Preparation of a practical, comprehensive manual on the use of medium to small wind electric systems. Includes analysis of siting, engineering aspects and economics through the use of worksheets and programmable calculator programs. Development of programmable calculator programs and documentation for an engineering and economic analysis of solar domestic hot water systems. Investigation into the energy balance for small scale farm alcohol stills. Development of a computer model to calculate the net available biomass and fuel potential at any specific site in the Midwest. Compilation of a bibliography on energy for agriculture with an international emphasis.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0030
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
Flegal CJ, Dept. of Poultry Science, Michigan State University, *East Lansing, Michigan, 48823,* (MICL01064)
OBJECTIVE: Develop optimal animal manure management systems to meet evolving environmental and economic requirements and be compatible with increasing needs for animal protein. Characterize atmospheric contaminants and develop abatement methods to eliminate contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses. Characterize non-point pollution water runoff sources from livestock and poultry enterprises on pasture production systems and land areas with manure application and further develop guidelines for abatement of non-point pollution sources from animal manures.
APPROACH: Waste management systems presently employed in Michigan will be monitored and evaluated for improved design for machinery management technique and collection alleyways. Determine the influence of feeding an odor suppressant to broilers and laying hens in relationship to feed efficiency, weight gain, and fecal odors. Study of anaerobic organisms in poultry anaphage. Upgrading the crude protein of anaphage. Study the calcium and postasium availability from poultry anaphage. Study the amino acid availability by employing turn-over rate estimates, involving radio labeled amino acids.
PROGRESS: A performance study of a fixed-position flat plate solar collector was made. Collector efficiency varied with air flow rate, daily insulation level and seasonal position of the sun. On clear days in January and February the collector delivered about 16 cents worth of heat per square meter of collector per day. This value was calculated on a Btu of fuel oil equivalent with oil at $1.00 per gallon, 140,000Btu/gallon and a 50 percent efficiency. Also, a simulation model was operated to determine the effect of various house design and management factors upon the moisture removed from a cage-type poultry house. Building insulation, waterer surface, photoperiod and lighting energy had little influence upon removal. Moisture removal increased with increased ventilating, manure surface, housing rate, bird weight and inside temperature during one season.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0031
CHARACTERIZATION OF CLIMATE AND ASSESSMENT OF IMPACT ON AGRICULTURE AND OTHER RENEWABLE RESOURCES
Baker DG, Seeley M, Dept. of Soil Science, University of Minnesota, *St. Paul Minnesota, 55101,* (MIN-25-064)
OBJECTIVE: Characterize the time and space distribution of climatic parameters that relate to agriculture production; extend and improve the climatic and environmental data base; organize project results and information into forms readily available to users; implement the research aspects of the National Climate Program that pertain to agriculture and renewable resources.
APPROACH: Climate variables will include solar radiation, ppc, soil moisture and soil temp. Time distribution to evaluate extremes and probability values for weekly and monthly periods will be determined and their impact upon agricultural production will be assessed through the use of models. A network for improved observations will be expanded to provide one station at the intersection of every 4 townships for ppc, 20-30stations for seedling depth temperatures and approx. 50 sites across Minn. for soil moisture. Models will be developed for such application as irrigation scheduling, and crop development estimates. User oriented forms will include summarized data and distributed through the Cooperative Extension Service and other State and Federal agencies. The above relates to the objectives of the National Climate Program.
PROGRESS: The monitoring of solar radiation at 5 stations across the state plus the monitoring of all fluxes of radiation at St. Paul continues. A new measurement at St. Paul is the incoming solar radiation on a surface oriented 55 degrees from the horizontal. This is a common elevation of solar collection panels (that is, latitude plus 10 degrees) in order to receive the maximum radiation on an annual basis. A pyrheliometer that tracks the sun (normal incidence pyrheliometer) is also on order. Several new studies using the solar radiation data collected over the years are nearing completion. One shows a simple empirical method that can be used to estimate the direct beam radiation from measurements that contain the total (direct beam plus diffuse) radiation. A second study shows the relatively limited distance that can be tolerated between sunshine and radiation stations for the prediction of radiation from sunshine. A seasonal bias occurs with respect to the distance. For example, for a given correlation coefficient the sunshine and radiation stations must be closer together in the winter than in the summer. A directional bias was not detected. The paper dealing with the climatology of wind and wind energy is nearing completion.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0032
STRUCTURES, EQUIPMENT AND ENERGY USE FOR POULTRY PRODUCTION
Reece FN, Lott BD, Deaton JW, South Central Poultry Research Lab., U.S. Dept. of Agriculture, Agricultural Research, *Mississippi State, Mississippi, 39762,* (7414-20400-002)
OBJECTIVE: Develop design criteria for structures, equipment, and energy use that will improve production efficiency and reduce environmental stress for poultry production systems.
APPROACH: Factors that determine design criteria for structures, equipment and energy use for poultry production and delineate environmental stress will be studied through the use of environmental research chambers, experimental buildings, and equipment for poultry production. Systems for application of alternate energy sources such as solar, wood, and waste products will be developed and evaluated for on-farm heating of poultry houses.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

9.0033
ADOPTION AND DIFFUSION OF ENERGY CONSERVATION TECHNOLOGY
Eastman CE, Dept. of Agricultural Economics & Agribusiness, New Mexico State University, *Las Cruces, New Mexico, 88003,* (NM-1-5-27766)
OBJECTIVE: To determine the extent to which lack of information hampers adoption of energy conservation technology, and to identify and/or develop and field test appropriate communication models for diffusion of energy conservation technology.
APPROACH: The impact of information on technology adoption will be determined by a questionnaire survey of recent adopters. A random sample of households will receive a concentrated informational campaign together with pre-and post-tests to determine cognitive impacts. Communication model(s) will be developed from the questionnaire data. One or more models will be tested and assessed through use in experimental information campaigns.
PROGRESS: A set of energy saving techniques is being assembled which will provide the basis for the questionnaire items in the survey. These techniques include categories: solar, insulation, fireplaces and stoves, and landscaping. Potential sampling frames of recent adopters are being explored and evaluated.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0034
DEVELOPMENT OF AN ENERGY SYSTEM BASED ON BIO-MASS ENERGY, SOLAR ENERGY AND ABSORPTION HEAT PUMP
Tilak A, Dept. of Industrial Engineering, University of North Carolina, *Greensboro, North Carolina, 27411,* (NC.X-022-5-79-430-4)
OBJECTIVE: To develop, build, and test an energy system based on three technologies: solar heating, biomass energy generator, and absorption heat pump. The cost effectiveness of the system will then be studied.
APPROACH: The first step in the proposed project will be to determine specifications for each component of the total system. The next step will be to build a prototype system that meets the specifications. The system performance data will be collected regularly and will be analyzed to determine the cost effectiveness of the system.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0035
POTENTIAL AREAS OF ENERGY CONSERVATION AND USE OF ALTERNATE ENERGY SOURCES IN AGRICULTURE IN N.C.
Goswami DY, Dept. of Mechanical Engineering, University of North Carolina, *Greensboro, North Carolina, 27411,* (NC.X-020-5-79-440-4)
OBJECTIVE: Study of current on-farm practices as followed in the state of North Carolina. Assessment of the energy needs of different farm operations in North Carolina. Identification of the areas of maximum potential for energy conservation and where solar energy and other non-conventional energy can be used.
APPROACH: The first phase of the project will in-

volve the study of current on-farm practices in North Carolina which use some form of energy. At the same time an extensive literature review of energy research work in agriculture will be done. Energy use by each of the operations will be calculated and compiled. An economic analysis will be done to identify the potential for energy conservation and use of alternate sources of energy in agriculture.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0036
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
Lindley J, Brumel MC, Haugse C, Dept. of Agricultural Engineering, North Dakota State University, *Fargo, North Dakota, 58103*, (ND01422)
OBJECTIVE: Conceptualize, develop, analyze, and optimize animal manure management systems with least cost and energy requirements for pollution control compatible with changing socio-politico-economic patterns. Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein.
APPROACH: The adaptability of various manure management systems to conditions that exist in North Dakota will be evaluated. Housing for beef, dairy, poultry, and hogs will be included in the work. Both installation costs and operating costs will be considered in developing economic appraisals of systems. The energy required to install and operate equipment will be measured when new facilities are installed. The water vapor that is released in various handling systems will be determined. The quantity and quality of gases will also be measured. The odors generated and the effects of manure on runoff will be related to various systems of land spreading. The effectiveness of stabilization of manure by microorganisms will be measured along with the degree of control that can be achieved with pathogenic organisms. Insect control will be included in this phase of the work. Systems utilizing solar or wind energy for manure de-watering will be tested. Briquetting and other processes that may facilitate utilization of manure will also be included in the work.
PROGRESS: Lagoon Effluent: The effect of spreading lagoon water on a shelterbelt has been under study since 1972 by Robert Heintz of the Horticulture Department. Soil samples have been taken to evaluate possible nutrient build-up in the soil profile. An economical distribution system was installed this summer. A single coil (7.6m) of corrugated plastic pipe with 1.25 cm diameter holes was placed in the middle of the shelterbelt. Hole spacing varied from.15m to.30m. Anaerobic Treatment of Swine Waste: Low temperature anaerobic treatment of swine waste is being studied by Dr. Paul Holmes of the Department of Bacteriology. The microflora of laboratory scale digesters started from hog waste lagoon samples and did not adapt efficiently to low temperatures when operated isothermally at 4 degrees C and 15 degrees C for one year.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0037
ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES
McMartin W, Dept. of Agricultural Economics, North Dakota State University, *Fargo, North Dakota, 58103*, (NRE-43-309-38-01)
OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood and home heating. Analyze the economic feasibility of energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.
APPROACH: Assess the economic resource use and environmental implications of public programs to encourage "energy farms." Develop regional reports on current land and water use, the economic implications for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregional linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empircal studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

9.0038
SYSTEMS APPROACH TO TOBACCO MECHANIZATION
Huang BK, Johnson WH, Sowell RS, Dept. of Biological & Agricultural Engineering, North Carolina State University, *Raleigh, North Carolina, 27600*, (NCO2504)
OBJECTIVE: Characterize biological factors related to producing and processing tobacco; reduce labor and production costs; improve tobacco quality; develop technology for greater modification and control of tobacco properties; optimize use of solar energy in greenhouse bulk curing system; improve efficiency of tobacco marketing system.
APPROACH: Laboratory, field, greenhouse, and computer modeling studies to: determine optimal conditions for uniform seed germination and seedling growth; identify economic mechanized system for production of high quality transplants and for transplanting; further mechanize and reduce energy requirements for harvesting and curing; relate process variables of curing to leaf and smoke chemistry for improved quality; study solar energy utilization in a greenhouse bulk curing system; evaluate and compare alternative market systems; further evaluate and test the concept of close-grown tobacco; develop computer models to optimize production systems.
PROGRESS: Studied effect of various seed treatments and operational/physical factors on seedling uniformity under mechanized hydroseeding tests. Direct seeding trials of Oriental/flue cured tobaccos gave satisfactory plant stands/yields. Greenhouse grown transplants compared favorably with bare root transplants in field study. Developed a mechanoelectronic device to automatically sort seedlings by size. Three-year data collection program involving 40 harvester years indicated a field capacity of 0.34 ha/hr, field efficiency of 59.7%. Evaluated effect of harvest schedule on crop value. Developed technique for determining optimum crop area for harvester. Built and tested leaf distributor, for filling curing boxes, controlled by density of leaf passing through system. Multi-chamber solar curing system with heat recovery showed fuel savings up to 70% vs. typical farm systems. Continuous air-flow instrumentation incorporated into energy modeling studies. Five microprocessor controlled bulk box tobacco cures conducted in solar barn; handling problems were simplified with mechanically harvested tobacco. Hydroponic vegetable production and peanut drying tests conducted in solar barn. Tested farm feasibility of curing tobacco in modern barns using steam/hot water heated with wood pellets and cord wood.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0039
DESIGN AND CONSTRUCTION OF 600 WATT FREE-PISTON STIRLING ENGINE
Scheck C, Sunpower Inc., *Athens, Ohio, 45701*, (1607)
OBJECTIVE: Sunpower proposes to design, construct, test, modify, and prepare for prototype demonstration a 600 Watt output free piston Stirling engine-alternator. This demonstration unit will be adaptable to operate on a wood stove as well as any source of high temperature heat (biogas, concentrated solar energy, agricultural field waste, etc.). The prototype unit will be propane fired for inital testing and will be complete in all respects, including engine-alternator, cooling system, and control unit. It will produce 60 hz ac 120 volts and 12 volts dc. It will be capable of a long life (10,000hours) without repair or recharging. Its working fluid will be pressurized helium. It will be designed to produce minimum noise and external vibration in order to be compatible with living spaces.
SUPPORTED BY: U.S. Dept. of Energy.

9.0040
UTILIZATION OF WASTE FROM VEGETABLES PROCESSING PLANTS
Geisman JR, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691*, (OHO00636)
OBJECTIVE: Evaluate compaction and drying methods for reducing sludge volume produced in spent brine recycling; methods for reducing water volume for freshing salt stock cucumbers, dehydration techniques for recovering by-products from tomato processing; and develop ways for using solid waste from cabbage processing.
APPROACH: Studies will be done in commercial processing plants and the laboratory. Wastes will be collected and subjected to compaction, separation, and extraction of the various components by dehydration, reverse osmosis, partial pressure, combustion, and chemical treatments as applicable. Emphasis will be placed upon the development of usable products and energy sources and the efficiency of the procedures required to recover such products from the plant wastes. Solar energy sources for recovery will be tested.
PROGRESS: Spent curing brine was recycled using the pH adjustment method and applied to the eight batch of cucumbers. After curing, these cucumbers were evaluated for quality with no deleterious effect. When compared to a lot cured in fresh brine, less bloating resulted from recycling. Another lot was treated by pH adjustment with the addition of 6 ppm of an anionic polyelectrolyte with resultant highly acceptable quality. The polyelectrolyte treatment could serve as a management tool. If cucumbers were being received by the plant faster than brine was being recycled then the addition of polyelectrolyte would be warranted. If this were not the case, then management could decide whether to apply this treatment or utilize the 48 hour period in scheduling brine recycling. Several thermophilic organisms were screened for their ability to rapidly convert cellulose to available carbohydrates and upgrade protein content. Organisms which gave favorable results would be applied to cabbage waste to rapidly degrade and convert it for possible animal feed use. One organism, Sporotricum thermophile, shows much promise and does not produce mycotoxins. Shallow pan fermentations indicate an excellent rate of conversion of cellulosics to usable materials. Tomato wastes including seeds, peels and cores, after being freeze dried and ground are being evaluated as a potential food additive. This material has potential for adding both high quality protein and pigments.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0041
ENGINEERING ANALYSES OF ENERGY STORAGE FOR AGRICULTURAL USES
Keener HM, Roller WL, Short TH, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691*, (OHO00613)
OBJECTIVE: Evaluate known or synthetic systems for collection and storage of solar, waste, electrical or bioprocess heat for their applicability to conserve fossil fuels in agricultural systems.
APPROACH: Determine the functional characteristics of heat-dependent agricultural processes which may be amenable to substitution for fossil fuel heat. Determine the operating characteristics of candidate heat collection and storage devices. Determine, by systems analysis, the optimum match between collection/acquisition rate and heat storage capacity for each of the heat dependent processes, based upon criteria of fuel availability, space, or cost, etc. Specify and publish example systems which are feasible solutions to meeting heat requirements of agricultural process systems.
PROGRESS: Heat storage tank shapes analyzed for surface area to volume ratios. Results suggest that for an open top structure, a cylindrical storage structure with radius equal to height and a hemispherical bottom would have the minimum

surface to volume ratio. In an isothermal environment, this structure would minimize heat loss during heat storage. Studies on the non-isothermal environment are underway. Experimentation on the heat collection and storage with a solar pond 8.5 x 18.3 x 3 meters continued. The maximum temperature reached during 1978 was 57.0 degrees C and represents a heat storage of 62x109J. Heat extraction equipment has been tested for heating of a greenhouse. Simulation of a high temperature collector (Owens-Illinois SunPak) coupled to a large storage system for use in providing heat for 10,000bushel grain drying system started. Collector area versus tank sizes studied for years 1970-1977 at Wooster, Ohio. This collector-storage system would cost over 18 times more than current electric/gas drying systems. Cost curves showing allowable cost of heat storage for grain drying developed. Simulation of animal heat recovery systems and high temperature solar collectors coupled to storage for use in providing heat for process dairy water (on the farm) continued. Experimental equipment procured and installation begun for field study of a total heat system for a 100-200 cow dairy herd. Field experimentation results showed water at 38-40 degrees C returning from heat recuperator.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0042
ALTERNATIVE ENERGY HEATING OF DAIRY PROCESS WATER
Roller WL, Keener HM, Elwell DL, Ohio Agricultural Research & Development Center, *Wooster, Ohio, 44691,* (OHO00274-Ss)
OBJECTIVE: Determine, demonstrate, and disseminate factual information on the management of alternative energies (such as animal heat in the milk, solar heat collected, and offpeak electric energy) to decrease the demand for fossil fuel energy in the heating of Process Water on Ohio's Dairy farms.
APPROACH: An operating dairy production facility is available as a part of the new OARDC Dairy Research Center. Alternative energy conservation system interactions have been modeled on the computer using design parameters as used by the Dairy Research Center architect for heating and storage capacities and process requirements. The simulation-optimum system of animal heat recovery, solar heat collection and off-peak electric heat make-up will be demonstrated by retrofitting to the facilities now nearing completion. All solar collectors used will be commercially available units as is the animal heat recovery and off-peak electric heating will be made. Factual information on energy savings will be disseminated via on-site field days and through the written, oral, and visual media.
PROGRESS: Several computer simulations were run to find the best combination, connection, and management strategy for the use of in-line milk coolers, bulk-tank cooler condenser heat recuperators, solar water heaters, and electric off-peak heaters in the heating of process water for dairy production units. Commerical equipment has been selected, matched and installed (with the exception of the solar collectors) in a production unit of the OARDC Dairy Research Center. A new generation of evacuated-tube, glass-tube, water-heating collectors is scheduled for installation in March 1979. Simulation suggests that about 60-65% of the process heating needs will be met by the recovery of heat from the milk cooling system, about 30-35% will come from the solar collectors and the last 5-10% will come from off-peak electrical resistance heat. In the short time in December that the system, less the solar collectors, was in operation, the temperature of water heated by heat recovered from this milk cooling system tended to verify this estimate. Since this project is basically a grant-funded energy conservation demonstration, considerable effort has been expended to cluster, arrange, and display the essential elements of the process water heating system and the performance data collection system.
SUPPORTED BY: Ohio State Government.

9.0043
AGRICULTURAL STRUCTURES DESIGN UTILIZING ALTERNATE ENERGY SYSTEMS, MATERIALS AND CONCEPTS
Hellickson ML, Dept. of Agricultural Engineering, Oregon State University, *Corvallis, Oregon, 97331,* (ORE00360)
OBJECTIVE: Design and develop structures for lambing in high winter rainfall climates. Design, construct, and test a simple solar powered apparatus that will develop shaft power. Compare overall heat transfer characteristics of typical greenhouse glazing materials. Design, construct, and test low cost apparatus to provide freeze protection for nursery tree seedlings. Investigate utilization of non-fossil energy in livestock and plant production systems.
APPROACH: Investigate structural modifications that will improve conditions for lambing ewes and newborn lambs reared in high winter rainfall climates. Construct a solar powered apparatus that will produce shaft power by heating bimetallic coils. Test various greenhouse glazing materials to compare overall heat transfer characteristics. Construct and field test low cost radiant heaters designed to provide freeze protection for nursery tree seedlings. Investigate and assess various alternate energy sources and energy conservation schees that have potential for reducing energy consumption, and/or replacement of conventional energy sources.
PROGRESS: Progress has been made on the solar powered apparatus designed to provide shaft power. Several modifications of mechanical configuration and the incorporation of two plastic linear fresnel lenses has provided periodic rotation of the mechanism. Current modifications including addition of a fly wheel and multiple energy conversion devices are nearly completed. Additional testing of the basic concept with modifications is required. Comparison of the overall heat transfer characteristics of various greenhouse glazing materials including flat and corrugated fiberglass and a single layer of polyethylene has been completed. Results of this study indicated that energy savings expected by flat fiberglass over corrugated fiberglass would be equal to the difference in exposed surface area rather than projected surface area. Development and installation of freeze protection of nursery tree seedlings continues. Installation of approximately 9.3 m 2 of flat plate solar collectors and a water cooled condenser has been completed at the OSU Dairy Center. The system has been in operation approximately 3 months. Data are being accumulated to provide projections of systems performance and economics.
SUPPORTED BY: Oregon State Government.

9.0044
ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES
Bailey M, Wenderoth J, U.S. Dept. of Agriculture Economic Development Div., University of Pennsylvania, *Philadelphia, Pennsylvania, 19104,* (NRE-43-309-42-06)
OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood and home heating. Analyze the economic feasibility of energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.
APPROACH: Asses the economic resource use and environmental implication of public programs to encourage "energy farms." Develop regional reports on current land and water use, the economic implications for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregional linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empirical studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.
SUPPORTED BY: U.S. Dept. of Agriculture, Economics & Statistics Service.

9.0045
ENERGY IN WESTERN AGRICULTURE-ADJUSTMENTS, ALTERNATIVES AND POLICIES
Harman WL, Lacewell RD, Lepori WA, Agricultural Research & Extension Center, Texas A & M University, *Amarillo, Texas, 79106,* (TEX03408)
OBJECTIVE: Evaluate alternative governmental policies affecting energy use and availability in agriculture and in the food and fiber industry. Analyze impacts of changes in energy prices and supplies on production, processing, distribution, and consumption of food and fiber. Evaluate alternative technologies and management systems for dealing with changes in energy costs and availability.
APPROACH: Since irrigation power costs make up over 60 of the cost of crop production in the Texas High Plains and energy prices continue to escalate, this analysis will evaluate alternative energy sources such as wind and biomass for use in supplementing farm production energy needs. Partial budgeting, investment analysis and linear programing of whole farm units will be used to evaluate the economic feasiblity and government incentives needed to develop these alternative sources of energy. Sudden energy supply shortages and continued rising prices will be evaluated for the potential impacts on the farm and production practices. Improved engineering concepts in design and efficiency of alternate energy production will be evaluated with the objective of improving the economic feasibility and farm profits.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0046
ENERGY CONSERVATION AND ALTERNATIVE ENERGY SYSTEMS IN RURAL AREAS
Petersen HC, Chatelain L, Dept. of Economics, Utah State University, *Logan, Utah, 84321,* (UTA00029)
OBJECTIVE: Determine the impact of higher energy prices on residents of rural areas. Assess current energy conservation practices in rural areas. Investigate the attitudes of rural residents with respect to energy conservation practices. Determine special problems associated with energy conservation in rural areas. Evaluate the economic feasibility of using alternative energy systems such as wind and solar in rural areas.
APPROACH: Data necessary to accomplish objectives 1-4 will be obtained from surveys of rural and urban residents in the state of Utah. Additional data will be obtained from utility records. Data will be analyzed using standard statistical methods. Objective #5 will be accomplished by colleating data from energy suppliers and existing studies. Using computer simulations and life cycle costing, the costs of building and operating solar and wind energy systems in rural areas will be determined. Also, interviews and a search of the literature will be used to determine special advantages and disadvantages of alternative energy systems in rural areas.
SUPPORTED BY: Utah State Government.

9.0047
SOLAR/WIND ENERGY TO COOL TOBACCO STORAGE WAREHOUSES TO PROVIDE INSECT CONTROL
Iachetta FA, Childs DP, Dept. of Mechanical Engineering, University of Virginia, *Charlottesville, Virginia, 22901,* (7093-20620-004-A(1))
OBJECTIVE: Determine energy requirements for cooling and maintaining tobacco storages at 4 degrees C during winter months and examine solar energy alternatives for powering either vapor compression or absorption refrigeration units to provide thermal conditioning and wind energy driven fans for air cooling and circulation.
APPROACH: Tobacco stored in a representative sheet metal warehouse in central North Carolina will be monitored for rate of heat transfer. Heat emission from warehouse walls and roof will be measured, and methods selected to economically reduce this type of radiation. Size and cost of solar and/or wind powered cooling systems having capacity to chill warehouse air to cool tobacco packed in hogsheads to 4 degrees C or lower for 12

consecutive weeks during winter months will be determined.
PROGRESS: A computer program has been developed to model a refrigeration system and thermal response of a tobacco warehouse located in central North Carolina. The program computes the heat load on the building, subtracts heat which can be removed by thermal siphoning and active refrigeration and adjusts the inside temperature to accommodate the remaining heat. The program is used to evaluate performance expected from passive cooling systems, solar collectors, absorption refrigeration components, and growth of ice during the year in an underground storage tank. Insect life in the stored tobacco will be destroyed during the fall season by thermal siphoning of cool ambient air into the warehouse and during the winter by air whose temperature is controlled by heat exchange with water from the ice storage tank. Temperature of the warehouse and its load will not exceed 4 degrees C over an 8- week period during the winter season.
SUPPORTED BY: U.S. Dept. of Agriculture, Agricultural Research.

9.0048
ENERGY REDUCTION FOR ON-FARM PROCESSING OF AGRICULTURAL PRODUCTS
Baker JL, Vaughan D, Kline RG, Graduate School, Virginia State University, *Petersburg, Virginia, 23806*, (VA-622356)
OBJECTIVE: Determine energy consumption of various harvesting, processing, and storage systems. Reduce or substitute for fossil fuel required in existing systems for processing agricultural crops. Develop new energy efficient systems for processing agricultural products. Perform an economic analysis of new and existing processing systems.
APPROACH: Review energy consumption data from controlled experiments and on farm data. Determine specific input energy per unit of output. Alternate energy conserving management systems for drying and curing hay, grain, and tobacco will be evaluated. Solar and wind energy will be evaluated. Solar and wind energy used to dry and cure tobacco and hay in alternate packages. Insulation and modified handling techniques will be evaluated. Determine economic optimum methods/machines/systems for harvesting, processing, and storing specific crops for specific types of farms. Use census, cooperative crop reporting service, and land grant university data.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0049
OPTIMIZE EFFICIENCY OF ENERGY UTILIZATION IN AGRICULTURAL HOUSING SYSTEMS
Vaughan DH, Graduate School, Virginia State University, *Petersburg, Virginia, 23806*, (VA-622357)
OBJECTIVE: Increase efficiency of energy utilization in agricultural housing systems through development and evaluation of technological and management alternatives.
APPROACH: Feasible alternatives for using energy more efficiently in existing housing systems will be designed and developed. Design will be based largely on conventional technology that can be transferred to housing systems. Any managerial procedures and alternatives that can result in using energy more efficiently will be revised. When appropriate, alternate energy sources, such as solar, biomass, and wind will be utilized to conserve fossil fuels in any retrofitting designs. Specifically, a solar assisted heat pump will be used to heat a pig nursery. Three groups of pigs will be raised in the facility during the winter. Overnight heat storage will be accomplished by using inexpensive ponds.
SUPPORTED BY: U.S. Dept. of Agriculture, Cooperative Research Office.

9.0050
ALE ADMINISTRATION
Rogers LE, Battelle Pacific Northwest Lab., U.S. Dept. of Energy, *Richland, Washington, 99352*, (000618)
OBJECTIVE: The Terrestrial Ecology Program is an integrated ecosystem level research effort designed to ascertain the implications of energy development in the semi-arid regions of the western states. Basic to evaluating potential environmental stresses associated with energy development technology is an understanding of how the shrub-steppe ecosystem functions and its response to perturbations. This program is dedicated to providing the data base essential for environmental evaluation of a multitechnology basis: coal, oil shale, natural gas, oil, nuclear, solar, and geothermal.
SUPPORTED BY: U.S. Dept. of Energy, Office of Health & Environmental Research.

9.0051
APPLICATION OF SOLAR HOT WATER AND GEOTHERMAL TECHNIQUES TO CLOSED CYCLE AQUACULTURE
Yansito RA, R.A. Yanzito Consulting Service, *Whitewater, Wisconsin, 53190*
OBJECTIVE: Recent advances in aquaculture systems around the world coupled with the increasing need for realistically priced protein encourage continued investigation. Developments in environmentally controlled systems in the State of Wisconsin coupled with that state's decline in fish production underline the need to investigate the commercial feasibility of such systems. To date, the cost of conducting closed cycle aquaculture in Wisconsin would not provide an adequate return on investment. A major contributor to this problem has been the cost of heating the water and maintaining a temperature level which would encourage the growth of food fish. The investigation seeks to solve this problem through the application of geothermal principles to provide a friendly environment and solar hot water to raise the well water to the required temperature. An aquaculture system of the size proposed (50,000pounds per year) would normally consume some 15,690gallons of fuel oil and 554,100kilowatt hours of electricity annually. The application of solar and geothermal would eliminate the fuel oil requirement and substantially reduce the electricity consumption. The proposed research will synthesize a number of ideas into a manageable fish rearing system. The basic concept entails the design of an underground silo where warm water food fish could be raised to market size under controlled condition.
SUPPORTED BY: U.S. Dept. of Energy.

9.0052
DRYING AND STORAGE OF FUEL CHIPS
Henriksson R, Gustafsson G, Dept. of Farm Buildings, Swedish University of Agricultural Sciences, *Lund, Sweden, S22006 Lund 6*, (52 1160 152)
OBJECTIVE: The purpose of the project is to examine, analyze and solve those problems which are connected with artificial drying and storage of fuel chips and other kinds of biomass for energy use. Practical and economical investigations will be worked out. Every year 4,5000,000 tons of felling waste is produced in Sweden. This waste wood corresponds to 2,000,000 tons of oil. To make this waste wood to a future energy source the problems with drying and storage must be solved.
APPROACH: During this period comparative drying in model scale will continue with different kinds of fuel chips. Experiments with relative humidity control, temperature control, and time clock control will be made to reduce the energy demand for the drying. Methods for thin-layer drying and batch drying will be developed. Drying with cold air and drying with heated air from solar collectors and other heat sources will be examined further.
PROGRESS: Results from drying experiments during the first period are reported in Spec.medd. 97, Department of Farm Buildings, Swedish Univ. of Agr. Sciences. Results from experiments with solar collectors for drying are reported in CIGR-paper IV-2b-4,1979.
SUPPORTED BY: Namnden for Energiproduktionforskning.

9.0053
RENEWABLE ENERGY SOURCES IN THE SWEDISH ENERGY SUPPLY
Bubenko JA, Mattsson C, School of Electrical Engineering, Kungliga Tekniske Hogskolan, *Stockholm, Sweden, S10044 Stockholm*, (53 0560 131)
OBJECTIVE: A preliminary analysis of impact and performance of renewable energy sources in the Swedish utility systems.
APPROACH: The following areas will be considered in the project which is divided into two parts: 1. Consequences of small grid-connected wind power stations. 2. Economy of small grid-connected wind power stations. 3. Wave power in the utility systems. 4. Photovoltaics in the utility systems. 5. Large wind power stations in the utility systems. 6. Renewable energy sources in integrated energy systems. Step I - The pilot study: This part of the project comprises literature studies and an overview of the state of the art. Problems of special interest are going to be identified and areas for further studies will be selected. The pilot study is intended to be completed in the beginning of 1981. Step II - Studies in selected areas: Deeper analyses will be performed in the areas specified in Step I. Wave power is one area of primary interest as well as consequences of different penetration of renewable energy sources into the electric systems. Step II will start early in 1981.
SUPPORTED BY: Namnden for Energiproduktionforskning.

SUBJECT INDEX

Commercial Buildings

Educational Facilities

Farm Buildings

Greenhouses

Residential Housing

Single Family Housing

Storage Facilities

BY-PRODUCTS

See Also Feed Science and Technology
See Also Food Engineering and Technology
See Also Product Development

ECONOMICS

Economic Impact

Economic Methods and Measures

Budget Analysis

Input-Output Analysis

Production Controls

Projections and Forecasts

Simulation

Trends and Cycles

Economic Methods - Other

ENERGY SOURCES - ORGANIC

See Also Waste Treatment-Biological
See Also Waste Types

Bioenergy Conversion

Biomass Conversion

Buildings, Energy Use

Commercial Use

Energy Efficiency

ENGINEERING

See Also Design Criteria

ENGINES

See Mechanical Power

ENVIRONMENTAL IMPACT

See Also Air Pollution

Fossil Fuels

Fuel Produced From Organics

Fuel Produced From Wastes

Gaseous Fuel

INDUSTRIES

Canneries

Chemical Industries

Dairy Industries

Energy Industries

Fiber Industries

Food Processing Industries

Forest Industry

Grain Industry

Greenhouse Production

Livestock Industries

Plant Industries - Other

Processing Industries

KILNS

LIQUID FUELS

See Fuels

LIVESTOCK

Beef Cattle

Dairy Cattle

Poultry

NITROGEN

NUCLEAR ENERGY

NUTRIENT SOURCES

OCEAN ENERGY

See Energy Sources - Natural

OILSEED AND OIL CROPS

See Crops

OXIDATION

WASTE TYPES

INVESTIGATOR INDEX

PERFORMING INSTITUTION INDEX

University of Florida, Lake Alfred
1.0038, 1.0039, 4.0024, 7.0021
U.S. Department of Agriculture, Forest Service, Lehigh Acres
6.0018
University of Florida, Sanford
6.0019
U.S. Department of Agriculture, Agricultural Research, Winter Haven
1.0040

GEORGIA

U.S. Department of Agriculture, Agricultural Research, Athens
9.0014
University of Georgia, Athens
1.0041 1.0042, 1.0043 1.0044, 1.0045, 1.0046, 1.0047, 6.0020, 6.0021, 6.0022, 6.0023, 7.0022, 7.0023, 9.0012, 9.0013
U.S. Department of Agriculture, Forest Service, Athens
5.0009
Georgia Institute of Technology, Atlanta
5.0010, 9.0015
U.S. Department of Agriculture, Agricultural Research, Dawson
4.0025
University of Georgia, Experiment
1.0048, 6.0024
U.S. Department of Agriculture, Agricultural Research, Savannah
1.0049
University of Georgia, Tifton
1.0050, 1.0051, 9.0016, 9.0017, 9.0018

HAWAII

University of Hawaii, Honolulu
1.0052, 1.0053, 4.0026, 4.0027, 6.0025, 6.0026, 6.0027
U.S. Department of Agriculture, Forest Service, Honolulu
6.0028
La Maloo Dried Fruit, Pahoa
9.0019

IDAHO

University of Idaho, Moscow
3.0011, 3.0012, 4.0028, 4.0029
U.S. Department of Agriculture, Agricultural Research, Twin Falls
1.0054, 6.0029

ILLINOIS

U.S. Department of Agriculture Forest Service, Carbondale
1.0055
U.S. Department of Defense, Army Corps of Engineers, Champaign
5.0011, 7.0024, 7.0025
Davy McKee Corp., Chicago
4.0030
Market Facts, Inc., Chicago
1.0056
Giltedge Farms Inc., Freeport
4.0031
Illinois State University, Normal
4.0032
U.S. Department of Agriculture, Agricultural Research, Peoria
4.0033, 4.0034, 4.0035, 4.0036, 4.0037, 4.0038
U.S. Department of Agriculture, Economics & Statistics Service, Peoria
1.0057
University of Illinois, Urbana
1.0058, 1.0059, 1.0060, 1.0061, 4.0039, 4.0040, 4.0041, 4.0042, 4.0043, 4.0044, 4.0045, 4.0046, 4.0047, 4.0048, 6.0030, 6.0031, 7.0026, 8.0004, 8.0005
Southeastern Illinois College, Vienna
7.0027
Performing Institution Not Reported
4.0049, 5.0012

INDIANA

Indiana Biolab, Palmyra
7.0028
Purdue University, West Lafayette
1.0062, 1.0063, 1.0064, 1.0065, 1.0066, 4.0050, 4.0051, 4.0052, 4.0053, 4.0054, 4.0055, 4.0056, 4.0057, 4.0058, 7.0029, 7.0030, 8.0006, 9.0020, 9.0021, 9.0022, 9.0023
Performing Institution Not Reported
1.0067, 4.0059, 4.0060, 7.0031, 7.0032

IOWA

Iowa State University, Ames
1.0068, 1.0069, 1.0070, 1.0071, 1.0072, 1.0073, 1.0074, 2.0003, 4.0061, 4.0062, 4.0063, 4.0064, 4.0065, 4.0066, 4.0067, 5.0013, 5.0014, 7.0033
University of Iowa, Iowa City
1.0075, 1.0076

KANSAS

Benedictine College, Atchison
7.0034
Kansas State University, Manhattan
1.0077, 1.0078, 1.0079, 2.0004, 4.0068, 4.0069, 4.0070, 5.0015, 5.0016, 6.0032, 6.0033, 7.0035, 7.0036, 9.0024
U.S. Department of Agriculture, Agricultural Research, Manhattan
4.0071

KENTUCKY

University of Kentucky, Lexington
1.0080, 1.0081, 1.0082, 1.0083, 5.0017, 9.0025, 9.0026

LOUISIANA

U.S. Department of Agriculture, Forest Service, Alexandria
5.0018
Louisiana State University, Baton Rouge
1.0084, 1.0085, 1.0086, 1.0087, 2.0005, 4.0072, 4.0073, 4.0074, 6.0034
U.S. Department of Agriculture, Agricultural Research, Houma
6.0035, 6.0036, 6.0037
U.S. Department of Agriculture, Agricultural Research, New Orleans
2.0006, 4.0075

MAINE

University of Maine, Orono
1.0088, 5.0019

MARYLAND

U.S. Department of Agriculture, Beltsville
1.0090

U.S. Department of Agriculture, Agricultural Research, Beltsville
2.0007, 6.0038
U.S. Department of Agriculture, Federal Research Office, Beltsville
1.0089
University of Maryland, College Park
1.0091, 1.0092, 1.0093, 4.0076, 4.0077
U.S. Department of Commerce, National Bureau of Standards, Gaithersburg
7.0037

MASSACHUSETTS

University of Massachusetts, Amherst
1.0094, 1.0095, 1.0096, 1.0097, 2.0008, 5.0020 0
Dynatech Research & Development Co., Cambridge
4.0078, 7.0038
U.S. Department of Defense, Army, Natick
7.0039

MICHIGAN

University of Michigan, Ann Arbor
5.0021, 5.0022, 7.0040
Advanced Systems Associates, Bloomfield Hills
1.0098
Michigan State University, East Lansing
1.0099, 1.0100, 4.0079, 4.0080, 4.0081, 5.0023, 7.0041, 9.0028
Michigan Technological University, Houghton
5.0024
Amon Cherrywood Farms, Williamsburg
2.0009

MINNESOTA

University of Minnesota, Duluth
5.0025
University of Minnesota, Navarre
7.0042
University of Minnesota, St. Paul
1.0101, 1.0102, 4.0082, 4.0083, 4.0084, 4.0085, 4.0086, 5.0026, 5.0027, 5.0028, 5.0029, 6.0039, 6.0040, 8.0007
Performing Institution Not Reported
3.0013

MISSISSIPPI

U.S. National Aeronautics & Space Administration, Biloxi
6.0041
Alcorn State University, Lorman
6.0042
U.S. Department of Agriculture, Agricultural Research, Meridian
6.0043, 6.0044
Mississippi State University, Mississippi State
1.0103, 1.0104, 5.0030

MISSOURI

University of Missouri, Columbia
1.0105, 1.0106, 1.0107, 1.0108, 1.0109, 2.0010, 4.0087, 4.0088, 4.0089, 4.0090, 5.0031, 5.0032

MONTANA

Montana State University, Bozeman
3.0014, 4.0091, 4.0092, 7.0043
University of Montana, Missoula
5.0033, 5.0034
U.S. Department of Agriculture, Forest Service, Missoula
5.0035

NEBRASKA

U.S. Department of Agriculture, Agricultural Research, Clay Center
4.0093
University of Nebraska, Lincoln
1.0110, 1.0111, 1.0112, 1.0113, 1.0114, 2.0011, 4.0094, 4.0095

NEVADA

University of Nevada, Reno
3.0015, 6.0045, 8.0008

NEW HAMPSHIRE

University of New Hampshire, Durham
5.0036, 5.0037
U.S. Department of Defense, Army Corps of Engineers, Hanover
8.0009

NEW JERSEY

Harbor Branch Foundation, Lawrenceville
6.0046
Rutgers University, New Brunswick
1.0115, 1.0116, 1.0117, 1.0118, 1.0119, 4.0096, 4.0097, 5.0038, 7.0044, 7.0045, 7.0046
Princeton University, Princeton
7.0047

NEW MEXICO

University of New Mexico, Albuquerque
1.0120
Southwest Research & Development Co., Las Cruces
2.0012
New Mexico State University, Las Cruces
5.0039
Ramah Navajo School Board, Inc., Ramah
1.0121

NEW YORK

State Bureau of Science Education, Albany
1.0122
State University of New York, Albany
6.0047
Four Seasons Solar Products Corp., Farmingdale
1.0123
Ocean Pond Corp., Fishers Island
2.0013
New York State Agricultural Experiment Station, Geneva
4.0107, 6.0048
Cornell University, Ithaca
1.0124, 1.0125, 1.0126, 1.0127, 1.0128, 2.0014, 2.0015, 4.0098, 4.0099, 4.0100, 4.0101, 4.0102, 4.0103, 4.0104, 4.0105, 4.0106, 5.0040, 5.0041, 5.0042, 6.0049, 7.0048, 7.0049, 8.0010, 8.0011, 8.0012
Chemical Systems Inc., New York
4.0108

NORTH CAROLINA

North Carolina Agricultural and Technical State University, Greensboro
1.0129, 1.0130, 1.0131
North Carolina State University, Raleigh
1.0132, 1.0133, 1.0134, 1.0135, 1.0136, 1.0137, 4.0109, 4.0110, 5.0043, 5.0044

NORTH DAKOTA

North Dakota State University, Fargo
1.0138, 4.0111, 4.0112, 4.0113, 4.0114, 4.0115, 7.0050

OHIO

Sunpower Inc., Athens
9.0039
Battelle Memorial Institute, Columbus
5.0045, 6.0050
Ohio State University, Columbus
4.0116
Ohio State University Research Foundation, Columbus
4.0117
U.S. Department of Agriculture, Forest Service, Delaware
6.0052
Solar Central, Mechanicsburg
1.0139
University of Toledo, Toledo
2.0016
Sherwood Forest Products Inc., Waverly
1.0140
Ohio Agricultural Research & Development Center, Wooster
1.0141, 1.0142, 1.0143, 1.0144, 1.0145, 1.0146, 1.0147, 4.0118, 6.0051, 8.0013, 9.0040, 9.0041, 9.0042
Performing Institution Not Reported
2.0017

OKLAHOMA

Oklahoma State University, Stillwater
1.0148, 1.0149, 1.0150, 1.0151, 1.0152, 1.0153, 4.0119

OREGON

Oregon State University, Corvallis
3.0016, 4.0120, 4.0121, 4.0122, 5.0046, 5.0047, 9.0043
U.S. Department of Agriculture, Forest Service, Portland
5.0048, 5.0049, 5.0050
U.S. Department of Energy, Portland
7.0051
Hitek, Inc., Sweet Home
1.0154

PENNSYLVANIA

General Electric Co., Philadelphia
6.0053
Hahnemann Medical College & Hospital, Philadelphia
7.0052
University of Pennsylvania, Philadelphia
9.0044
U.S. Department of Agriculture, Economics & Statistics Service, Philadelphia
1.0155
Pennsylvania State University, University Park
1.0156, 1.0157, 4.0123, 5.0051, 6.0054, 6.0055, 6.0056, 7.0053, 8.0014

RHODE ISLAND

University of Rhode Island, Kingston
4.0124, 5.0052, 5.0053

SOUTH CAROLINA

University of Georgia, Aiken
7.0054
U.S. Department of Agriculture, Forest Service, Aiken
6.0058
U.S. Department of Energy, Aiken
7.0055
Clemson University, Blackville
4.0125, 6.0059
Clemson University, Clemson
1.0158, 1.0159, 1.0160, 1.0161, 1.0162, 1.0163, 1.0164, 4.0126, 4.0127
University of South Caroiina, Columbia
4.0128
Colleton County Government, Walterboro
7.0056

SOUTH DAKOTA

First Baptist Church, Aberdeen
1.0165
South Dakota State University, Brookings
1.0166, 1.0167, 1.0168, 1.0169, 1.0170, 1.0171, 2.0018, 2.0019, 2.0020, 4.0129, 4.0130, 4.0131, 7.0057, 7.0058

TENNESSEE

Tennessee Technological University, Cookeville
2.0021
University of Tennessee, Knoxville
1.0172, 1.0173, 1.0174, 8.0015, 8.0016
U.S. Department of Agriculture, Agricultural Research, Knoxville
1.0175
U.S. Tennessee Valley Authority, Knoxville
7.0059
Oak Ridge Associated Universities Inc., Oak Ridge
7.0060
University of Tennessee, Oak Ridge
6.0060
U.S. Department of Energy, Oak Ridge National Lab, Oak Ridge
4.0132, 7.0061, 7.0062
U.S. Tennessee Valley Authority, Norris
5.0054, 5.0055, 5.0056

TEXAS

Texas A&M University, Amarillo
9.0045
U.S. Department of Agriculture, Agricultural Research, Beaumont
1.0176
U.S. Department of Agriculture, Agricultural Research, Bushland
2.0022, 2.0023
West Texas State University, Canyon
2.0024
Texas A&M University, College Station
1.0177, 1.0178, 4.0133, 4.0134, 4.0135, 4.0136, 5.0057, 5.0058, 7.0063, 8.0017
Texas A&M University, Lubbock
5.0059
Texas A&M University, Weslaco
6.0061, 6.0062, 6.0063

UTAH

Utah State University, Logan
6.0064, 6.0065, 9.0046
U.S. Department of Agriculture, Forest Service, Ogden
5.0060
Utah Roses, Inc., Sandy
3.0017

VERMONT

University of Vermont, Burlington
1.0179, 5.0061, 5.0062, 5.0063, 6.0066

VIRGINIA

Tetra Tech Inc., Arlington
2.0025
Virginia Polytechnic Institute & State University, Blacksburg
1.0180, 1.0181, 1.0182, 1.0183, 2.0026, 2.0027, 6.0067
University of Virginia, Charlottesville
9.0047
Mitre Corp., McLean
4.0137
Virginia State University, Petersburg
9.0048, 9.0049
Roanoke Independent Source of Energy, Salem
1.0184
Norm Hodges & Associates Inc., Springfield
1.0185

WASHINGTON

Bellingham Vocational Technical Institute, Bellingham
2.0028
State Department of Natural Resources, Olympia
6.0068, 6.0069
U.S. Department of Agriculture, Agricultural Research, Prosser
1.0187
Washington State University, Pullman
1.0188, 1.0189, 1.0190, 1.0191, 5.0067
U.S. Department of Energy, Richland
7.0064, 9.0050
Ecotope Group, Seattle
1.0186
University of Washington, Seattle
5.0064, 5.0065, 5.0066

WEST VIRGINIA

West Virginia University, Morgantown
6.0070, 7.0065

WISCONSIN

Southwest Wisconsin Vocational Technical Institute, Fennimore
4.0138
University of Wisconsin, Madison
1.0192, 1.0193, 2.0029, 4.0139, 4.0140, 4.0141, 4.0142, 5.0068, 6.0071, 7.0066, 7.0067, 7.0069
U.S. Department of Agriculture, Forest Service, Madison
1.0193, 5.0069
U.S. Department of Agriculture, Forest Service, Rhinelander
6.0072, 6.0073, 6.0074
Seymour Community Schools, Seymour
1.0194
R.A. Yanzito Consulting Service, Whitewater
9.0051
Performing Institution Not Reported
5.0070, 7.0068, 8.0018

WYOMING

Wyoming Rural Electric Assn., Casper
1.0195
University of Wyoming, Laramie
2.0030, 5.0071

EGYPT

Gameat Al Iskandaria, Alexandria
1.0196
American University in Cairo, Cairo
1.0197

INDIA

Central Arid Zone Research Institute, Jodhpur
1.0198
Indian Agricultural Research Institute, New Delhi
4.0143

POLAND

Research Institute on Environmental Development, Wroclaw
4.0144

PUERTO RICO

University of Puerto Rico, Mayaquez
6.0057

SWEDEN

Swedish University of Agricultural Sciences, Alnarp
2.0031
Ergonomi Design Cruppen AB, Bromma
6.0075
Chalmers Tekniska Hogskola, Goteborg
1.0200, 5.0072
Interforest AB, Lidingo
5.0073
Svenska Devel AB, Linkoping
8.0019
Swedish University of Agricultural Sciences, Lund
1.0199, 4.0145, 9.0052
Norra Smalands Energigrupp AB, Nassjo
5.0074
Studsvik, Energiteknik AB, Nykoping
7.0070
Sikob AB, Sollentuna
5.0075, 6.0076
Forskningsstiftelsen Skogsarbeten, Stockholm
5.0076
Kungliga Tekniske Hogskolan, Stockholm
5.0077, 7.0071, 9.0053
Fjarrvarme AB, Trosa
4.0146, 5.0078
Alfa-Laval AB, Tumba
7.0072
Swedish University of Agricultural Sciences, Umea
6.0078
Jordbrukstekniska Instituten, Uppsala
4.0148
Swedish University of Agricultural Sciences, Uppsala
3.0018, 4.0147, 5.0079
Sodra Skogsagarna, Vaxjo
6.0077